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## **Accelerated electrification of road transportation and uniform payment solutions in the Nordic countries**

A report conducted by Sopra Steria on behalf of The Swedish Energy Agency

## Executive summary

Transport is an important element to the economy, both in terms of the social aspect of connecting people but also as an enabler for economic growth. However, the transport sector is also a large contributor to global greenhouse gas emissions and the electrification of vehicles is regarded as one of the major initiatives to lower emissions. The conversion to an electric transport sector is a key priority on both national and EU-level.

One of the major obstacles to transform the transportation sector is the user experience electric vehicle (EV) drivers face when paying for charging sessions at publicly accessible charging stations. The public charging landscape is fragmented with different payment solutions and interfaces which causes inconvenience for EV drivers, especially when travelling abroad.

The goal of the report is to map out today's payment landscape in the Nordic countries, as well as a selected number of European countries: France, Germany, Portugal, and The Netherlands. This report will serve as a basis for further work regarding EV payment solutions as a part of the project Accelerated Electrification of Roads Transport in the Nordic countries. The Swedish Energy Agency and The Nordic Council of Ministers have a joint ambition to facilitate collaboration between market actors to contribute towards uniform payment solutions on Nordic level, improving today's customer experience, and accelerating the growth in electrification of transportation.

There are several legislations, both proposed and implemented, that are expected to impact the current payment situation for EV-charging. On an EU-level, the policies Alternative Fuels Infrastructure Directive (AFID) and the proposed Alternative Fuels Infrastructure Regulation (AFIR) are considered the most influential. Being able to charge using an ad-hoc payment solution (without entering a contract with a charging service provider) is important in both AFID and AFIR. AFIR, though, goes one step further and has detailed payment with card or contactless functionality able to read cards as a minimum solution for EV charging.

This report confirms that the current payment landscape is indeed fragmented, but that the same payments solutions are to some extent provided in all the studied countries. The following payment solutions have been identified and are described in the report:

- Apps and RFID chips that only work at specific Charging Point Operators (CPO) charging stations
- Universal Apps and RFID chips that can be used on several different CPOs charging stations
- Card terminals for debit and credit card payments (including devices with a contactless functionality that is at least able to read payment cards)
- QR-Code and other web-based payment solutions
- SMS payments
- Plug & charge

Each of the identified payment solutions have been analysed in terms of advantages and disadvantages from a user, a vendor and a uniformity perspective. Some differences have been observed across the markets. In Portugal and the Netherlands, national roaming regulations mandates that payment must be possible through a universal app or RFID chip at all publicly accessible charging stations. No CPO-specific payment solutions are therefore available in Portugal or The Netherlands. The markets in the other countries appear more fragmented and all payment solutions are present to some extent. The use of card terminal and SMS vary significantly between the countries. There is also a difference in how "universal" the universal apps and RFID chips are, as some only work at two or more CPOs charging stations while others cover many stations domestically and even cross-border.

Card terminals are only present to a low extent on the markets studied in the report. This can be due to the perceived high cost connected to card terminals (hardware, installation and transaction fees) but also that card payment lacks the ability to harvest data such as charging time etc. The data can be used to improve and create value-added services and can be a reason why card terminals are not viewed as the preferred solution by CPOs.

The payment solutions offer different benefits to different stakeholders. Vendors can achieve a customer lock-in effect by providing a CPO-specific app, RFID chip or use Plug & charge as a payment solution. It can also be a strategic priority to become the leading provider of a payment solution such as universal apps or RFID chips, or to maximize market reach through offering the option to pay with ad-hoc payment solutions. The choice of payment solution can also be impacted by national legislation, as seen in Portugal and the Netherlands for universal apps and RFID chips, or through proposed legislation from EU on requiring possibility to pay ad-hoc through solutions such as card terminal, QR-code or web payments.

Initiatives to harmonize the payment solutions on a national level are in progress in some of the Nordic countries. In Sweden, there is an initiative started by the former Minister of Energy to gather the industry to decide on a future payment strategy as well as Swedish roaming platform initiative. In Norway, The Ministry of Transport has proposed a new transport plan that promotes a more uniform payment strategy for public charging as well as an initiative on a universal RFID chip from the Norwegian Electric Vehicle Association. Denmark has recently proposed and implemented a law that requires all future public EV charging stations to support card payments as a minimum requirement.

The report concludes that card terminals offer an easy alternative to quickly reach a uniform payment solution that also aligns with existing and proposed regulations from the EU. However, many other payment solutions offer additional services that can provide significant customer value. A mix of payment solutions may present the best alternative to not only enable easy payment of EV charging today but also capture the full potential of a data driven future.

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# 1 Introduction

This report is written by Sopra Steria on behalf of the Swedish Energy Agency as a part of the project Accelerated Electrification of Road Transport in the Nordic Countries that is funded by The Nordic Council of Ministers. The Swedish Energy Agency has requested an overview of existing payment solutions for charging stations in selected countries so that The Nordic Council of Ministers can evaluate the potential for a uniform payment solution in the Nordic countries as they have pointed out the importance of co-operation across borders, especially between the Nordic countries, to increase the efficiency and pace of the transition process to fossil-free transportation.

## 1.1 Background

Transport is the backbone of the economy – connecting people, jobs, and services – enabling trade and economic growth, but it also acts as a large contributor to global greenhouse gas emissions. Electrification of vehicles is regarded as one of the major initiatives to lower emissions and is a key priority on both national and EU level. Several initiatives exist to accelerate the transition from fossil-fuel vehicles to electric vehicles.

The electric vehicle (EV) market, including Battery and Plug-in hybrid EVs (BEV and PHEV), is undergoing a substantial growth that is predicted to continue the coming years. Consequently, there will be a high demand for infrastructure, such as charging points, both in public and in private space. Lack of charging infrastructure is expected to be a barrier to the shift to EVs.

The transition to EVs has created a new market for charging that is different from paying for fuel at a gas station. EV drivers currently experience a heterogenous landscape with different payment solutions and interfaces when utilizing public charging stations which among many things causes confusion and frustration. Mobile applications, credit and debit cards, QR-codes, web page solutions and SMS payment are all payment solutions offered on today's EV market in the EU.

Another issue connected to many of these payment solutions is that they require advance registration before charging, so called "contract based charging sessions". This practice complicates the charging process and creates another restriction for EV drivers. Card terminals, which is the standard for uniform, ad-hoc payments, are considered expensive and not available as standard for public EV charging.

The EU and several member states have recognized the need for harmonization of the EV charging market. Regulations that address the need for uniformity and ad-hoc payments are in progress or to some extent already in place. It is at this point not clear neither if the proposed legislation will provide sufficient framework to create a functioning market nor if the proposed technical solutions are optimal for all parties involved.

There is today no overview of the landscape for payment solutions that can provide a roadmap for Sweden or the Nordic countries. Just the impression of a fragmented market that can impede the transition to EVs. More in-depth knowledge about the market landscape and the existing solutions is necessary to provide a basis for further discussions on establishing a uniform payment solution for EV charging.

## 1.2 Research objectives

This report aims to present the current situation and context of today's payment solution for public charging stations in the Nordic countries, as well as a few countries representing different approaches to payment solutions – The Netherlands, Portugal, Germany and France. The findings will serve as a foundation to evaluate conditions for a uniform payment solution for EV within the Nordics. The research objectives of this report are as following:

- a) A compilation of existing payment solutions in the Nordic countries, the Netherlands, Portugal, Germany, and France.
- b) The potential basis for chosen payment solutions for public charging stations.
- c) Steering mechanisms to control and incentivize uniform payment solutions for charging stations based on initiatives such as the AFID, proposed AFIR and ITS.
- d) A compilation of ongoing initiatives related to payment solutions and uniformity in the Nordic countries.
- e) Strengths and weaknesses of existing payment solutions for users, charging service operators, and the potential of being a common Nordic solution.

Each objective will correspond to a different chapter in this report

### **1.3 Limitations**

While this report explores different payment solutions for EV charging, only payment solutions currently available on the EV charging market today for the studied countries are included. More innovative payment solutions that are currently in test or pilot phase are not included. Further, only payment solutions for public charging of passenger cars are included. The following payment solutions will be explored in this report and are further defined in Chapter 2:

- smartphone applications (where this report differentiates between what will be defined as a CPO-specific app and a universal app)
- RFID chips (where this report differentiates between what will be defined as a CPO-specific RFID chip and a universal RFID chip)
- card terminals
- QR-code or other web-based payments solutions
- SMS payments
- Plug & charge

Some activities related to the payment situation is not relevant for the purpose of this report and is consequently not considered. Elements relevant to activate and pay for a public charging session are instead of focus and will be defined as "payment solutions" in this report. Other aspects related to payment for EV charging, for example whether the transaction is wired directly from the drivers account or if the driver receives an invoice, will not be included.

As this report explores the potential for a common Nordic payment solution, focus will be on the Nordic countries: Sweden, Norway Denmark, Finland and Iceland. However, certain other European countries are included in some parts of the report. The Netherlands, Portugal, Germany, and France are explored to gain further insight into payment solutions in the European EV charging market. The reason for exploring these countries was based on either the size of the country, or the perception that the market would differ significantly from the Nordic market and chosen in consultation with the Swedish Energy Agency. Other European countries will not be considered nor studied in this report.

Legislations on both EU level and national level is described in the report, but only the parts concerning payment solution for EV charging, and not on a detailed level. This report does not describe any legal aspects of the different payment solutions either. Definitions used in this report are defined in Chapter 2 and are not limited to local, regional nor EU's definition found in proposed and implemented legislation.

### **1.4 Approach**

The data and descriptions of payment solutions in this report are based on publicly available information that has been collected through desktop research. Information from workshops between Sopra Steria and The Swedish Energy Agency, internal workshops as well as insight and feedback from payment and transportation subject matter experts has also been included. Further, a reference group with representatives from national energy or transport authorities from all the Nordic countries has been involved during the process and have given input to the report.

Charging point operators or mobility service providers have not been interviewed directly and the solutions described in this report may therefore have features that are not described here.

## 2 Explanations and definitions

EV charging market consists of numerous market players, offering a range of charging and payment solutions. To ensure a common understanding throughout the report, this chapter will define uniformity, key players and concepts, explain the charging process and define relevant payment solutions.

### 2.1 Uniformity

In terms of public EV charging and uniformity, there is a common understanding that interoperability is necessary to promote and incentivize driving EVs at a larger scale. Creating uniform experiences and standardized solutions for drivers is seen as a key to enable both domestic travel and travel across national borders. When referring to uniformity in the context of payment solutions for public EV charging, this report implies that the EV driver should be able to use the same sort of payment solution independent of location, car brand and charging service providers. This could be seen from both a regional, national and international perspective – where an international standardized solutions being available to all types of customers in the same manner could be regarded as the highest level of uniformity. Uniformity therefore also implies the possibility to utilize the same payment solution across different vendors and operators.

### 2.2 Market players and concepts

The following market players and concepts play an essential role in today's EV charging market. As this report solely focus on payment solutions, it should be noticed that only relevant parts of the charging session will be defined and explored, i.e., only actors directly related to the customer payment interface.

It is also of importance to define the difference between charging point, -station and -pool as well as the concept of roaming related to public EV charging. The definition of public charging and the different steps of the process will be further presented in 2.2 Public charging and process.

#### 2.2.1 Charging point operator (CPO)

A charging point operator (CPO) deliver the physical charging stations used to charge electrical vehicles [1]. Each CPO distribute and operates a network of charging stations and are in that way building the charging-infrastructure [1]. A CPO are generally responsible for installation and maintenance of the charging stations. Many CPOs are expanding their business model by including products or services offered by mobility service providers, further described in 2.1.2 Mobility Service Provider (MSP) and are in that case both acting as an CPO and MSP [1].



**CPO**  
Charging Point Operator  
(Charging Service provider)

The European Union are currently working on defining the concept of a CPO for legislative purposes and have proposed the following definition: "operator of a recharging point' means the entity responsible for the management and operation of a recharging point, which provides a recharging service to end users, including in the name and on behalf of a mobility service provider" [2]. This definition is a part of the, by the European commission, proposed Alternative Fuels Infrastructure Regulation (AFIR) [2].

#### 2.2.2 Mobility Service Provider (MSP)

A mobility service provider (MSP) offers EV drivers access to a network of charging stations, usually by providing a RFID chip or app, or both. [3]. In addition to start, stop and pay for a charging session, mobility service providers might offer a wide range of services, including real time data for charging stations, and keep expanding their business model to differentiate themselves through new features [3]. These services are typically available for registered users, and unregistered customers are often provided with a more limited range of services but will often be able to manage and pay for the charging session [4].

An MSP might focus on providing charging access for one specific CPO's network or increase the number of charging points available through their network by signing roaming agreements [3]. An e-mobility service provider (EMSP) indicate that the solution is electrical [1], and related to public EV charging EMSP is often used interchangeably with MSP since most solutions are digital.



**MSP**  
Mobility Service Provider  
(Charging Service provider)

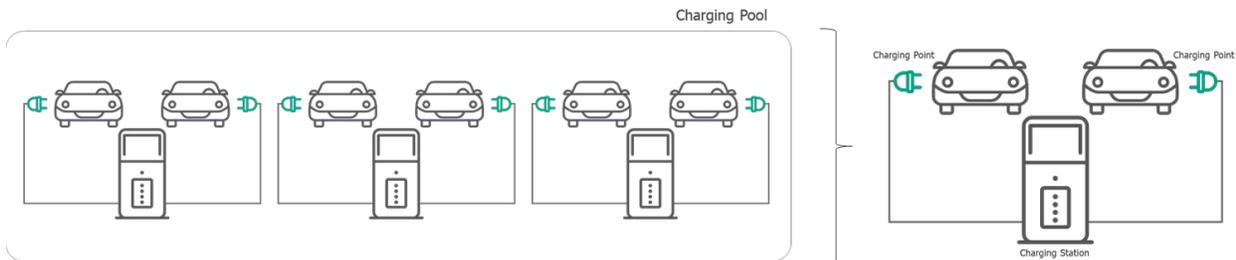
The European commission have also a proposed definition of MSP as part of the Alternative Fuels Infrastructure Regulation (AFIR): “‘mobility service provider’ means a legal person who provides services in return for remuneration to an end user, including the sale of a recharging service”. [2]

### 2.2.3 Charging service provider (CSP)

As mentioned, CPOs often operate as both CPO and MSP and defining and drawing the line between CPOs and MSPs gets continuously tougher. As the public EV charging market is progressively growing and evolving, new collaborations and services are continuously emerging [5] and the definition of Charging Service Providers (CSP) has been conceived as a convenient term to use for all actors contributing to the EV charging market [5].

### 2.2.4 Charging pool, charging station and charging point

An EV charging pool is a location equipped with one or more public charging stations from one CPO [6]. A charging station is the physical object, typically hanging on a wall or self-standing, that provides the customer with electricity throughout a charging point [7]. A charging station might have one or more charging points where each point corresponds to a spot where an EV can be plugged in and charged accordingly [7]. Public charging stations generally tend to have two or more charging points and one dedicated parking spot per point [7].



Only charging points are yet defined by the EU whereas the definition charging pool and station is only proposed in the Alternative Fuel Infrastructure Regulation (AFIR) [2]. AFIR defines a recharging station as a single physical installation for recharging vehicles and each charging station have at least one charging point that can only serve one vehicle at the time [2]. The number of recharging points at a recharging station determine the number of vehicles that can be recharged at that station at any given time meanwhile a charging pool is the designated area where one or several charging stations are located [2]. Charging pool could also include the dedicated parking lots adjacent to the charging station [2].

AC charging points with capacity of 22 kWh or less are referred to as normal chargers, meanwhile charging point of higher capacity are referred to as high-power or fast chargers by the EU [8]. Meanwhile, DC charging points are considered high-power at 50 kWh or above [8]. Operators and actors have varying definition of fast charging and at what capacity a charging point is considered high-power, often resulting in different charging rates, why the EU’s limit will be utilized for comparison and uniformity. Both normal and fast chargers will be considered in this report and will not be analysed separately since they are both accessible for most EV-drivers and the same payment solutions are in many cases provided by both.

## 2.2.5 Roaming

Roaming allows EV drivers to charge their car across various CPOs' charging stations by only utilizing one MSP. Roaming allows customers the possibility to create one account with their preferred provider and make payment to this single source [9], regardless of where the charging session have been completed within the roaming network.

Roaming networks might be provided in various extent and by different types of actors. Two or more CPOs might for example expand their charging network by signing a roaming agreement [9], and the customer will be able to use either one of the collaborating operators' payment solutions for all charging stations within the network.

Roaming can also be provided by third party solutions – roaming platforms – where the business model is based on connecting various MSPs and CPOs to one open Roaming network [10]. Customers might pay by using the third-party payment solution or any other preferred MSP's payment solution within the Roaming network.

## 2.3 Public charging

EU legislation defines a publicly accessible charging point as "a point which provides EU-wide non-discriminatory access to users", including

accessibility to payment solutions [11]. This imply that charging points not supporting ad-hoc payment, where the driver is required to enter some sort of contract to be able to charge, are not considered publicly accessible.

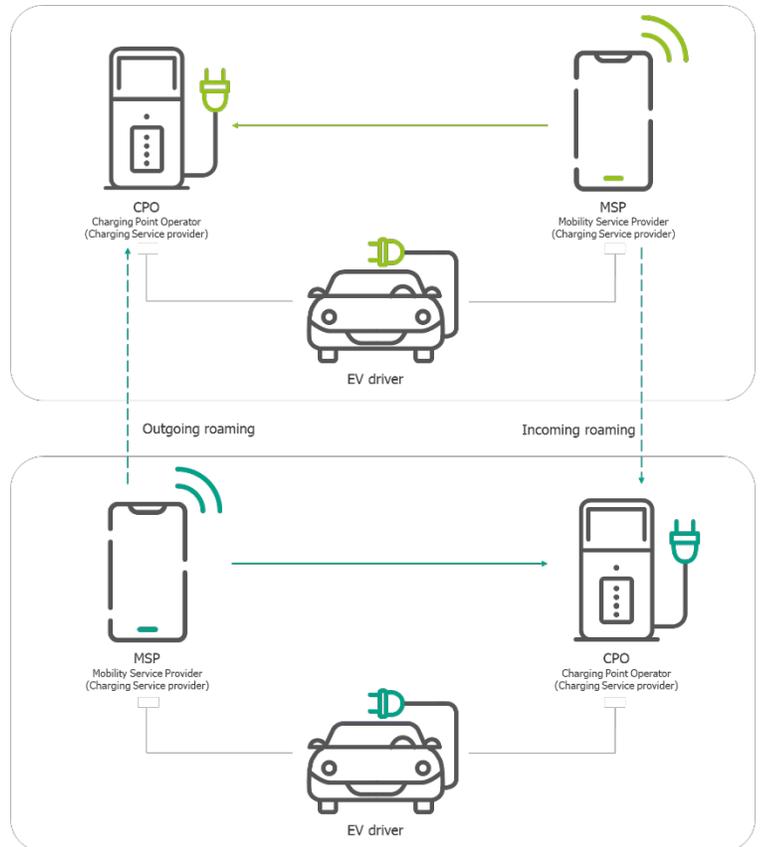
However, for the purpose of this report a wider definition is useful. As the report explores different payment solutions EV drivers are facing today, and the uniformity of these, all charging stations accessible for a considerable number of individuals are of interest and should be explored. As many of the identified actors in EU provides payment solutions that are not considered ad-hoc, this report will not make a distinction on whether a charging point is public based on available payment solutions. Given a sizable customer base, charging points available for specific car brands will be included in the definition as well.

### 2.3.1 The charging process

From a customer perspective, the charging process at publicly accessible charging stations might vary due to today's fragmented market with many operators with different business models. Which payment solutions that are provided will impact the process, but even with the same payment solution, the process might vary due to for instance different user interface. However, this section will describe some generic steps the driver most likely will need to complete.

#### 1. Preparation and registration

For certain payment solutions, preparations in advance of the charging session, like ordering an RDIF chip, might be required. Further, in many cases the customer needs to be registered as a customer to start charging. Downloading an app might be required in order to create the customer account. The next steps are described under the assumption that the driver has completed preparations and registration if necessary. Cases where the driver does not need to register in advance are referred to as "ad-hoc payments", in those cases this step is not required.





## 2. Connecting the charger

Before being able to start charging, the driver must connect the charger to the car. This is normally done before you initiate charging with one of the payment solutions, but in some cases the driver is required to initiate with a payment solution before connecting the charger to the car.



## 3. Choose payment solution

Available solutions at the relevant station might vary, but to start the charging session, the driver needs to choose a payment solution. The following payment solutions might be used at public EV charging stations (all will be described further in 2.3 Payment solutions):

- Swipe/tap a specific RFID card/tag
- Press “start” on a specific smartphone application
- Scan a QR code which directs you to for instance a website where you add your payment details (or other web-based solutions)
- Send SMS to a specific phone number
- Swipe/insert/tap credit card or debit card
- Plug & charge, where the charging starts automatically



## 4. Start and stop charging

In some cases, the customer might need to press “start” on the charging station to start the charging session, otherwise the charging is initiated as the payment solution is decided in step 4. There are several options to stop the charging session depending on what payment solution has been used to initiate charging. This could for instance be by pressing “stop” in the app, swiping the RFID card/tag or sending a SMS. For payment solutions such as QR code scanning or credit/debit card the user might need to press “stop” on the charging station itself. As for Plug & charge the user might be able to stop the session in the car or by pressing “stop” on the charging station. The driver can now unplug and drive off.



## 5. Invoicing

The customer will, dependent on the chosen payment solution, be invoiced accordingly. This could include direct transaction in real time, a specific invoice monthly or even adding the amount to the customers' phone bills.



## 2.4 Payment solutions

As earlier introduced, the EV public charging market is currently characterized by offering numerous different approaches and payment solutions, and what is referred to as a payment solution is vital to define. Payment solution is in this report defined as the object or function utilized to enable EV charging at publicly accessible charging points as presented in the charging process above.

The different payment solutions might be categorized based on the relation and agreement between the operator and the customer. "Ad-hoc payments" for public EV charging does not require any kind of commitment between the end user and the MSP in advance. This allows all EV driver to charge spontaneously at publicly accessible charging stations, regardless of nationality and member agreements [12]. "Contract-based payments" on the other hand, require a contract between the end user and the MSP in advance of the charging session [2]. "Automatic authentication" is a process where the authentication of a vehicle at the charging point is entirely automatized, with no interaction from the customer, and all the driver does is to plug in the charger at the designated charging station [2].

The payment relationship between the driver and operators also differs along other aspects, for example whether the transaction is wired directly from the driver's account or the driver receive invoice, but these aspects will not be considered in this report. The following payment solutions are the ones currently identified for publicly accessible charging points and will be described in more detail: RFID chip, App, Web payments, SMS, Card terminals and Plug & charge.

### 2.4.1 RFID chip (charging card/RFID tag)

Operators can offer drivers either a charging card or RFID tag as payment solution. Since both utilize a RFID chip and have close to identical payment process and user experience, this report will refer to both options as RFID chip. The RFID chips are usually ordered from the MSP to be delivered by mail but could also be bought in stores [13] [14]. The use of RFID chip is a contract-based payment solution, and before the charging session can start, the end user typically needs to register the RFID chip in the customer account for the relevant operators and add payment details [9]. To start and stop the charging session the chip needs to be placed at the RFID reader on the charging station. The process might be slightly different depending on vendors and type of charging station, and the driver might need to press start and stop as well [14]. The charging session will be charged according to payment details provided in the customer account [9]. [15]

A RFID chip might be provided by a MSP that also serve as a CPO, a company only serving as an MSP, or for instance a car company offering RFID chip as part of their product offering. Some RFID chips might only be used at charging stations from one specific CPO, in this report defined as "CPO-specific RFID chip", while others might be used across two or several different CPOs, called "universal RFID chip". Universal RFID chips can be utilized as a payment solution when roaming is available.

### 2.4.2 App

There are a range of different apps providing services related to public EV charging, including charging station maps, navigation assistance and real time data about availability to mention some [16]. To what degree the apps covers the different services varies, and for the purpose of this report, the focus will be on describing EV charging apps as a payment solution. App as a payment solution for publicly accessible charging stations is a contract-based payment solution, and before the charging session can start the user typically need to download the relevant app and create a customer account [9]. When arriving at the charging station, the driver needs to identify the relevant charging point

in the app, the details vary between different apps, but this might be done by for example finding the relevant charging point on a map [17]. Thereafter the driver can start and stop the charging session through the app and will be charged according to payment details provided in the customer account [18].

Just like RFID chip solutions, EV-charging apps might be provided by several different operators, including CPOs, car manufactures and companies operating only as MSP. While some apps might be used as payment solution for one specific CPO, called "CPO-specific app" in this report, other apps might be accepted as payment solution by different CPOs, called "universal app". Universal app might be utilized as a payment solution when roaming is available.

### 2.4.3 Web payments

There are different types of web payments for publicly accessible charging stations. One web payment solution involves finding a charging station available through a specific map and fill in card details [19]. However, using QR-codes seems to currently be a more common solution for accessing web payments (see Appendix B). QR-codes can be offered as an ad-hoc payment solution where the customer needs a smartphone camera to scan a QR-code placed at the charging point and is then automatically guided to a web interface where payment can be completed by for example adding payment card details [9]. QR-codes might be dynamic or static [20], and when the QR-code payment solution is available an alternative URL might be provided to reach the web page used for payment manually [21].

### 2.4.4 SMS payments

SMS as a payment solution for public EV charging is mostly offered as an ad-hoc payment solution [9] and works by sending an SMS to start and stop the charging session to a specific number [22]. The customer needs to include a specific code or text in the SMS as an identification of the charging point, but this along with the receiving number will typically be provided at the charging point [23] [24]. The driver will be charged through their regular phone bill [22]. Some operators requires that the customer sign up to varying extent beforehand, why SMS payments should not always be seen as an ad-hoc payment solution (see Appendix B). Whether SMS payments are available to non-domestic customers and whether the customer needs to be legally tied to a specific phone number by the phone operator is not explored in this report.

### 2.4.5 Card terminal

Card terminals accepting debit and credit card payments is a well-established payment solution for fossil-fuel vehicles and several other markets, and the concept is quite similar when card terminal is used as payment solution for EV charging. The driver will manage the charging session from the charging station and use card terminal to pay [25]. Payment with card terminal is offered as an ad-hoc payment that does not require the customer to sign up in any way in advance [9]. The convenience of this payment process will to some degree vary depending on whether the driver may swipe, insert, or tap the card, but all these alternatives, as well as other contactless payment solutions such as Apple Pay, and Google Pay will be defined as one payment solution in this report.

Card terminals generally support contactless card payments in the Nordic countries and for the purpose of this report, card terminals will be assumed to also include contactless functionality. Contactless functionality supports, in addition to contactless card payments from traditional debit and credit cards, payments with digital instances of payments cards such as Google and Apple pay.

### 2.4.6 Plug & charge

Payment solutions tend to require the customer to manually start the charging session. Plug & charge, on the other hand, offer an automatic authentication process where the EV will send the verification details when the charger is plugged in, and if accepted, automatically starting the charging session [26]. Likewise, the customer will automatically be debited for the consumed charging when the session is stopped either automatically or by the driver [26]. However, an agreement between the customer and the Plug & charge operator is required in advance of the charging, consequently making this payment solution contract-based [9]. The MSP for Plug & charge could be different types of market players, when offered by car brands the solution tends to be integrated in the EV interface, making it easily accessible for the EV driver.

### 3 Existing payment solutions

In 2020 Europe became the largest market for electrical vehicles and electromobility, with over 10% of all vehicles being electrical [27]. However, market design and accessibility of public charging station widely differs, both in terms of numbers and user interface. The following section will explore the different payment solutions today's EV drivers face in the Nordics and other selected European countries, including Germany, France, Netherlands, and Portugal. Because the EV charging market is developing rapidly, this section will focus on general market trends, and not focus on specific operators and individual findings in terms of market share etc.

If not referred to other references, information in this chapter is based on desktop research conducted for this report by looking into different charging service providers and gather information from their web page, this have been summarized in Appendix B. Blog posts, news articles and videos have been reviewed to aim an impression of the EV-driver experience in the relevant countries, but not used as direct reference. It should be mentioned that not all operators have been explored and the findings is not sufficient to describe the payment solutions for each country in detail but gives an indication of what payment solutions that is provided and to some degree how common they are.

#### 3.1 Overview of identified payment solutions

The identified payment solutions are all available in the explored countries to some extent. RFID chips and mobile apps are the most common payment solutions. On some markets there is a universal app and/or RFID solution while other markets are fragmented on this level as well with several CPO specific solutions. Sweden is a good example of this second-level fragmentation where EV drivers need to download several apps and register with each CPO to cover a sufficient geographical area. The availability of ad-hoc payments varies considerably between charging service providers and also between markets.

The following table summarize the identified payment solutions in the studied countries as well as providing a brief overview of current legislation related to public EV charging. Further information about each country will be explored in this chapter and information is based on the findings in Appendix B.

#### Identified payment solutions

	Sweden	Norway	Denmark	Finland	Iceland	Germany	France	Nether-lands	Portugal
<b>CPO-specific apps</b>	✓	✓	✓	✓	✓	✓	✓	x	x
<b>Universal apps</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>CPO-specific RFID chips</b>	✓	✓	✓	✓	✓	✓	✓	x	x
<b>Universal RFID chips</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Card terminals</b>	✓	x	✓	x	x	✓	✓	✓	x
<b>QR-code/web payments</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>SMS payments</b>	✓	✓	x	✓	✓	x	x	x	x
<b>Plug &amp; Charge</b>	✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>Regulations</b>	x	x	x*	x	x	Card terminals from June 2022	x	Roaming required	Roaming required

\*See Chapter 6.3 regarding recently adopted legislation in Denmark

All the studied countries utilized apps, RFID chips, some sort of QR-code/web payments and plug & charge. For countries that have legislated roaming, Portugal and The Netherlands, no CPO-specific apps or RFID chips have been identified. Card terminals are quite uncommon and in the studied countries, only a few actors have yet to install card terminals. Even in Germany, where new legislation soon will require all new charging stations to install card terminals, only a few actors seem to have widely implemented card payments. For most of the Nordic countries, SMS payments are available on the market meanwhile it has not been identified in several other European countries.

## **3.2 Sweden**

With low electricity rates compared to many other European countries, a great deal of all EV charging in Sweden is non-public, happening either at home or at work and over 65% of all EV drivers in Sweden are said to have private (non-public) access to charging stations [28]. Despite the stated difficulties related to fragmented payment solutions at public charging stations, Sweden is among several countries undergoing a steady increase of EVs [8] [28]. The fragmented market is seen as an effect of a wide variety of actors, both regional and international, fighting for market shares without any legislative steering.

A great part of publicly accessible charging stations in Sweden are operated by either traditional fuel companies utilizing the existing gas station network or by energy companies that also provides electricity. There are also available charging stations commonly run by real estate and parking companies. Some of the operators are collaborating with each other and utilizing the same technology, making it simpler for customers to charge within the network.

### **Payment solutions**

Payment options often include an operator specific RFID tag or charging card that can be utilized at the operator's charging stations where the customers are invoiced monthly. Charging station operators generally also have an app where you can pay directly when you charge by adding your debit or credit card details. A few charging operators also offers ad-hoc payment by installed card terminals, SMS payments or provided QR-codes but it is still considered unusual in Sweden.

There are a few alliances or collaborations between different charging operators in Sweden which enables the customers to use the same app, card, or chip at different operators' stations. Even so, there are MSPs that solely offers a uniform payment solution for private or commercial customers available at a network of charging operators. These providers generally offer a larger network of collaboration outside of Sweden and some covers most of the larger charging operators' stations in Europe.

Related to specific car brands and specific charging operators, there are also an automated charging and payment experience, so called Plug & charge, available in Sweden. This solution requires that the vehicle is compatible with the specific Plug & charge station and are currently not considered public by the definition of EU. Drivers are required to sign up and registering a debit or credit card to an account beforehand.

## **3.3 Norway**

Public EV charging in Norway is provided by different market players; CPOs, local authorities and businesses expanding their business models to become CPO, including energy companies, gas stations and car manufactures [29]. Considering all public EV charging providers offering one or more charging point, there are as of 2022 approximately 30-35 different active market players where many of those provide different charging experience and payment solutions [29].

CPOs often sign contracts with different service providers or stores/malls to acquire an attractive charging station location in Norway. For fast chargers, most charging stations are either located at shopping malls, grocery stores, gas stations or near accommodations and places to eat. Historically cheap electricity rates and well-established private charging, including smart home charging stations, also provides incentives for the fast increase of EVs in Norway [28]. As of January 2021, it is also compulsory to provide EV charging for all condominiums in Norway, making private charging further accessible in Norway [30].

## **Payment solutions**

A range of different payment solutions is offered in the Norwegian EV charging market [31] and like in Sweden, these might be provided through different market players and approaches. CPOs might provide payment solutions at their charging stations or leave it to a MSP.

Contractual payment solutions like apps and RFID chips are common payment solutions, and all CPOs in Norway offers payment with either CPO-specific or universal apps [32]. There are several collaborations, and apps and RFID chips might be used across certain different charging networks, but there is currently no official roaming agreement between all charging providers or any governmental legislation impacting this [31].

Ad-hoc charging by SMS payment is provided by most CPOs in Norway [32], but is also enabled at several charging stations by QR-code. QR-code as a payment solution can typically be completed by entering card details at the service providers web page, but one Norwegian operator recently introduced payment with Vipps, which is a well-known mobile payment application in Norway (similar to Swedish "Swish"). Charging might be two or three times as expensive when charging ad-hoc in Norway than by using contract-based payment solutions, especially for SMS payments [33]. Ad-hoc charging by SMS payment is provided by most CPOs in Norway [32], but is also enabled at several charging stations by QR-code. QR-code as a payment solution can typically be completed by entering card details at the service providers web page, but one Norwegian operator recently introduced payment with Vipps, which is a well-known mobile payment application in Norway (similar to Swedish "Swish"). Charging might be two or three times as expensive when charging ad-hoc in Norway than by using contract-based payment solutions, especially for SMS payments [33]. A couple of CPOs offers an Automatic authentication experience and payment is accomplished by Plug & charge.

## **3.4 Denmark**

Public chargers are mainly placed by highways, public parking areas and public buildings, as well as different private areas like gas stations and grocery stores [34]. There are several market players providing public EV charging, but two or three CPOs are covering most of the Danish charging network [34]. It should be mentioned that the EV market is continuously developing, and smaller market players are expanding their network. Compared to the two other Scandinavian countries, subscription model, where the driver pays a monthly fee for either charging at home, at public chargers or at both is more common in Denmark [34].

### **Payment solutions**

Like in Sweden and Norway, EV drivers in Denmark are facing several different payment approaches. App and RFID chip is common payment solutions. Many charging service providers act as both MSP and CPO, included two of the biggest operators, but there are also businesses operating as either a CPO or MSP [35]. This result in various payment solutions provided, both CPO-specific and universal apps and RFID chips. A great part of public charging points in Denmark is available through a roaming platform due to an agreement from 2021 where most market players committed to provide all EV drivers the possibility to pay across different charging networks [34]. Operators signing the agreement allow the driver to use payment solutions provided by other operators and the driver might chose to use the preferred solution. The price might however vary.

Some operators offer ad-hoc charging [35], for example by web-based solution where the driver enter a charging point ID and payment card details or by installed card terminals. The automated charging and payment experience, Plug & charge, is provided by a few operators, like in the two other Scandinavian countries described earlier.

## **3.5 Finland**

In comparison to the Scandinavian countries, there are fewer and larger CPOs in Finland, which would imply higher market entry barriers for smaller actors. Like the rest of the Nordic countries, the market consist mainly of traditional energy and fuel companies together with new actors that are only CPOs.

### **Payment solutions**

Like described for the Scandinavian countries, payment for EV charging in Finland is either provided by CPOs or MSPs. Both contractual and ad-hoc payment solutions seem to be common in Finland, whereas CPO-specific and universal apps and RFID chips are provided as contractual payment solutions and either SMS or web-based solution where the driver enter payment card details appears to be common ad-hoc solutions. Drivers are likely to be charged higher prices when utilizing Ad-hoc payments solutions. Identified charging providers seems to be part of networks

that tend to have an international perspective. A couple of CPOs offers an automatic authentication experience and payment solution by Plug & charge in Finland.

### **3.6 Iceland**

The findings of this research indicate that the EV charging market is operated by significant fewer companies than most other studied countries, but this could be since Iceland is smaller in terms of population and consequently have a smaller operational market in total. Charging is provided by both operators entering the market as CPOs, energy companies acting as CPOs and cooperation between the two.

#### **Payment solutions**

Identified charging service providers seems to be part of a larger network, and it appears to be two charging networks covering most of all charging points in Iceland, excluding plug & charge operators.

Payment with CPO-specific and universal app and RFID chip tend to be offered for a majority of charging stations, mostly offered by CPOs partnered up with an MSP. Ad-hoc payment is available at charging stations from at least two operators, typically provided through web-based payment solution and credit and debit cards terminals. Automatic authentication by Plug & charge is so far provided by at least two operators in Iceland.

### **3.7 Germany**

In addition to companies entering the market as CPOs, EV charging stations in Germany are generally operated by traditional fuel companies utilizing existing gas station networks, or energy companies. To reduce EV drivers concerns regarding charging, Germany announced in 2020 a proposition that all gas stations will require to offer EV charging as part of Germany's new increased electric-vehicle incentive package [36]. Further, the German government are fully invested in the development of more charging stations and public accessibility as they have passed on the law requiring all EV charging stations built from June 2023 to accept direct card payments [37].

#### **Payment solutions**

Both CPOs and MSPs provide payment solutions for EV charging in Germany. According to a report conducted by the Danish Ministry of Transport and the ministry of Climate, Energy and Supply [34] charging cards (defined as RFID chip in 2.3.1) is the most common payment solution in Germany. There is no RFID chip or app providing access to all charging points and EV drivers need to use different RFID chip and app depending on CPO. There are however several collaborations and MSPs providing access across more than one charging network by universal apps, often covering big parts of Europe. According to Last Mile Solutions, drivers are provided access to almost all major networks, but Berlin is an exception due to old-fashioned way of working there which makes it complicated to access the different networks for roaming [38].

Ad-hoc payment solutions seem to be provided by some operators, either by QR-code or by credit and debit card payments at installed card terminals. However, like mentioned above all charging stations installed from June 2023 must accept ad-hoc payment with debit or credit card. Like all other explored countries, a few CPOs in Germany also offers an automatic payment solution by Plug & charge.

### **3.8 France**

According to a report written by the consulting firm P3 many small CPOs are operating in France on a local level, which result in a heterogeneous EV charging landscape with many different actors [39]. It's natural to assume that payment solutions consequently lack consistency and uniformity.

#### **Payment solutions**

App and RFID chip, either provided by and MSP or CPO acting as an MSP, seems to be common payment solutions for the publicly accessible charging stations in France and in most cases the operator offers both payment options but can also offer either app or RFID chip. Several CPOs in France are either collaborating or taking part of some sort of alliance, where the available apps or RFID chips can be used across several CPOs. Several operators cover a larger international network and makes it possible for the driver to pay with the same app or RFID chip/charging card across most countries in Europe.

Some charging service operators offers Ad-hoc charging and while QR code seems to be the most common payment solution, some charging stations are equipped with card payment terminals. Some operators in France also offer Plug & charge as payment solution, available for specific car brands or models.

### **3.9 The Netherlands**

The Dutch EV charging market is operated by various CPOs and MSPs. If only considering fast charging stations, 78% of the approximately 450 stations is operated by four different CPOs [40]. Due to high installation costs the Dutch government and local authorities have cooperated with private businesses to offer more charging stations, which has resulted in a major part of the country's charging infrastructure being semi-public and placed at grocery stores, shopping malls and offices [31].

#### **Payment solution**

Like other explored countries, payment solutions in Netherlands might be provided by either an MSP or a CPO that also acts as an MSP. The charging service provider tend to offer payment with an app, RFID chip or both. The Netherlands have developed a protocol called Open Charge Point Interface (OCPI) and requires that all public accessible charging stations need to support this standard [34]. This standardization of payment solution enables the driver to pay with the same RFID chip for almost all public accessible charging stations in the Netherlands.

In terms of Ad-hoc payment, a price transparency benchmark conducted by The Netherlands Knowledge Platform for Charging Infrastructure in 2021, claims that only 42% of the charging stations they considered offered ad-hoc charging [40]. Further on, they find that the most common ad-hoc payment solution (62%) is by QR-code guiding the driver to a web page/app, and other options include payments via credit/debit card or by calling a telephone number [40]. A few charging operators offer automatic authentication through Plug & charge in The Netherlands. but these are currently not considered public by the definition of EU nor support the OCPI standard.

### **3.10 Portugal**

With the purpose of contribute to a more sustainable mobility model and accelerate the transition toward electric mobility, Portugal have created one standardized public charging network, the Electric Mobility Network (MOBI.E) [41]. The development of this public network started in 2008 and was established in 2015, integrated in the National Action Plan for Energy Efficiency [41].

#### **Payment solutions**

All operators offering public EV chargers on public land in Portugal needs to be part of the MOBI.E network, and EV drivers will gain access to all charging stations nationwide independent of specific CPOs or MSPs. Usually both app and RFID chip might be used to pay for EV charging, and these are provided by both MSPs an CPOs.

However, gaining access to the national roaming network generally requires a Portuguese app or RFID chip, why it might be difficult to utilize the network in Portugal for foreigners without signing up for a local agreement. Ad-hoc payment solutions are supported by some charging points by scanning a QR-code and entering payment card details. Automatic authentication is available through Plug & charge by a few operators but are not considered as a part of the public charging network by the Portuguese government since they are not connected to the MOBI.E network.

## 4 Potential reasons for choosing payment solutions

The following chapter explores potential reasons behind choosing different payment solutions from a CPO perspective. Identified payment solutions described in previous chapter will be explored, and since there might be various aspects for why a CPO chose one payment solution over another, each payment solution will be evaluated across five different dimensions:

- Market perspective
- Political perspective
- Technological perspective
- Financial perspective
- User perspective

This chapter will only focus on reasons for choosing different payment solutions, while weaknesses with the different solutions from a CPO perspective will be analysed in Chapter 7. Mainly generic reasons will be in focus in this chapter, but it should be mentioned that there might be individual differences between CPOs when considering the justification for choosing different payment solutions. A CPO often offers a combination of different payment solutions, as it might be complementing different aspects and attract different types of customers. However, exploring the basis of choosing combinations of different payment solutions will not be explored in this study but might be of interest for future research.

### Potential basis for choosing payment solutions

	Market perspective	Political perspective	Technological perspective	Financial perspective	User perspective
CPO-specific app	Lock-in effect on customer relationship		Scalability of software: Easy to expand business model and develop new services  Might be promoted as a modern/digital solution	Relatively low cost related to developing payment solution  Secure constant revenue  Few additional market players to split revenue with	Can potentially gain relevant user information to develop and improve services
Universal app	Competitive market, fighting to be standard solution  Opportunity for CPO to expand customer base  CPO alliances might be geographically strategic	Being part of a roaming network could be required by government, already introduced in for instance Portugal and expected in other countries	Scalability of software: Easy to expand business model and develop new services  Might be promoted as a modern/digital solution  Third parties offering roaming networks as a service lowering costs and complexity of connecting MSP and CPO	Relatively low cost related to developing payment solution  Potentially increase in revenue  Few additional market players to split revenue with	Offer convenient user experience  Can potentially gain relevant user information to develop and improve services
CPO-specific RFID chip	Lock-in effect on customer relationship		RFID technology is relatively simple	Relatively low cost related to developing payment solution  Secure constant revenue  Few additional market players to split revenue with	Customer loyalty  Doesn't require digital competence (after registration)  Doesn't require either smartphone or Internet

<b>Universal RFID chip</b>	Competitive market, fighting to be standard solution  Opportunity for CPO to expand customer base  CPO alliances might be geographically strategic	Being part of a roaming network could be required by government, already introduced in for instance Portugal and expected in other countries	RFID technology is relatively simple  Third parties offering roaming networks as a service lowering costs and complexity of connecting MSP and CPO	Relatively low cost related to developing payment solution  Potentially increase in revenue  Few additional market players to split revenue with	Offer convenient user experience  Doesn't require digital competence (after registration)  Doesn't require either smartphone or Internet
<b>Card terminal</b>	Wide market reach allowing ad-hoc payments (no sign-up required)	EU and national legislation might require credit/debit card payments (AFIR)  Credit-/debit card payments required in Germany for all new charging stations from June 2022	Well-established technology used for gas stations and other payment scenarios	Potentially increase in revenue	Doesn't require digital competence  Doesn't require either smartphone or Internet  Doesn't require registration in advance  Considered the "most" ad-hoc payment solution
<b>QR-code/web payment</b>	Wide market reach allowing ad-hoc payments (no sign-up required)	EU and national legislation might require ad-hoc payments  Proposed AFIR: QR-code accepted payment solution if <50kW	Scalability of software: Easy to expand business model and develop new services	Relatively low cost related to developing payment solution  Potentially increase in revenue  Few additional market players to split revenue with	Doesn't require registration in advance
<b>SMS payment</b>	Wide market reach allowing ad-hoc payments (no sign-up required)	EU and national legislation might require ad-hoc payments		Relatively low cost related to developing payment solution  Potentially increase in revenue	Doesn't require either smartphone or Internet  Doesn't require registration in advance  Require less digital competence
<b>Plug &amp; charge</b>	(Given customer base due to EV integrated service offerings)  High lock-in effect on customer relationship		Might be promoted as the most future oriented /digital solution		Customer loyalty by user-friendliness  Doesn't require digital competence (after registration)

## 4.1 Market perspective

When discussing potential reasons for choosing a payment solution from a market perspective, the CPOs objective to strengthen its position in the market should be explored. From a CPO's perspective, the so called "lock-in effect" which create a more loyal customer base and makes is less convenient to swich to other operators, might be motivation for choosing a CPO-specific app and/or CPO-specific RFID chip, as well as Plug & charge as payment solution. Offering attractive charging rates and other loyalty perks could be an efficient way to create returning customers for CPO-specific payment solutions.

A reason for choosing universal app or RFID chip could be the opportunity for CPOs to obtain a larger customer base, as allowing use of other MSPs or CPOs app and/or RFID card at the CPO's station potentially attracts more

customers. Since the CPO also can be an MSP, choosing a universal app and/or RFID chip might also be to try to position itself in the market as an MSP and become a standard payment solution in the market. Creating “Strategic alliances” to outcompete certain competitors, could also be a reason for choosing either universal app or universal RFID chip. For instance, two CPOs providing charging networks in different geographical regions might cooperate by allowing each other’s customers access to their charging network, using one universal app or RFID chip, as an effort to try to outcompete other CPOs having stations nearby.

CPOs operating in today’s EV-charging market might operate in additional markets where they potentially already offer one of the described payment solutions or provide other services through an app. For those cases it might be sufficient to develop already existing solutions which is likely to be a reason for choosing payment solution for EV charging. Most likely to be relevant for apps

Accepting payments from solutions such as SMS, QR-code/web or credit-/debit card terminals could from a market perspective be to maximize market reach, since such solutions do not require any prior sign-up, are accessible for the majority, and are well established ways of paying for other services in most countries.

## **4.2 Political perspective**

Looking at potential reasons from a political perspective there might be national or EU-level rules in place, or proposed legislation, that have impacted the basis for choosing a payment solution. Being part of a roaming network and thereby granting MSP access to your charging network could be required by the government or on EU-level, which then is a reason for choosing universal app and/or universal chip. This has for instance been the case in Portugal where all CPO must be part of the national network so that EV drivers can use one app or card at any public available station.

On EU and national level, legislation might also require the possibility of paying with ad-hoc solutions, thus being a potential reason CPOs choose to offer the opportunity to pay with SMS or QR-code/web payment. This can be seen in the proposed AFIR where QR-payment should be accepted for charging stations offering <50kWh. Proposed legislation (AFIR) or legislation already in place requiring the possibility to pay with a credit-/debit card could also be a potential reason this solution has been chosen by some CPOs. In Germany it is for instance required by law that all new charging stations build from June 2022 must accept credit-/debit card payments.

## **4.3 Technological perspective**

There might be several different reasons from a technological point of view to why a CPO chooses different payment solutions. This could for instance be related to the technology itself or technological development in general. A rationale for accepting payments via smartphone applications (universal/CPO-specific) or QR-code/web payment could be due to potential in the technology for expanding business by developing new services that are accessible through the application or on the website. Those services could for instance be paying for parking or the ability to book EV charging spots in advance.

Third party companies offering roaming networks as a service lowers the cost and complexity of connecting MSPs to CPOs and might therefore also be an argument accepting or investing in universal apps and RFID chips. Offering the option to pay by using an app (universal or CPO-specific) might also be chosen due to the public viewing the technology as modern. Further RFID chip (universal or CPO-specific) might be chosen based on the simplicity behind the technology.

Choosing to accept credit-/debit card might be seen as a safe option from a technical perspective due to the technology being well-proven and redundant as it has existed as a common payment solution in business-consumer relationship for a long time. Meanwhile, the rationale for choosing to invest in Plug & charge as payment option could be that the technology itself might be seen as the future as it offers fully automated experience, ease of use and can potentially give a competitive advantage for CPOs offering this solution.

## **4.4 Financial perspective**

When looking at potential reasons from a financial perspective, there are multiple arguments that relates to potential revenue and/or cost. On the cost side it could be related to development, installation, and maintaining the solutions, while on revenue side it can be linked to size of expected revenue and the risk regarding expected revenue.

The highest potential revenue will most likely be provided by universal payment solutions or ad-hoc solutions as they can be viewed as more attractive, user-friendly and have a higher potential market reach. This might be a reason for

choosing universal app, universal RFID chip, SMS payment, QR-code or card terminal. However, the basis for choosing the CPO-specific payment solutions, either app or RFID chip, might be that these solutions is likely to provide a more secure and constant revenue due to the "lock-in effect". From a CPO's perspective, saving money from not renting credit-/debit card terminals might be a reason choosing all described payment solutions except credit-/debit card itself. The cost of developing an app (universal or CPO-specific), RFID chip (universal or CPO-specific) or QR-Code/web payment solution is viewed as relatively low, being an argument for investing in such solutions.

Few market players to share revenue with might be a reason for choosing CPO-specific app, CPO-specific RFID chip, or QR-code/webpage solutions. Compared to SMS payment and card terminal, relatively few market players might be a reason for choosing universal app, universal RFID chip or Plug & charge as well. It should be mentioned that it might be desirable from a CPO's perspective to not depend on external parties for various reasons, not only financial.

#### **4.5 User perspective**

A user-friendly charging experience is vital for most EV drivers when choosing the preferred charging station [29], and the user perspective should be considered when looking at CPOs potential reasons for choosing the different payment solutions. The basis for choosing app, either CPO-specific or universal, might be the opportunity to gain user information that can be useful to improve already existing services or develop new services. Which again might result in increased customer loyalty by improving the user experience. Convenience is highly valued by EV drivers in charging-settings, and a motivation for offering a universal app or universal RFID chip might be to provide the drivers with a more convenient payment solutions compared to for instance CPO-specific app or RFID chip.

EV drivers have expressed that they appreciate the possibility to charge their car without having to complete any registration in advance, especially when they are driving through areas they are not normally in (other regions, cross-border), which is a potential reason for choosing payment by either SMS, QR-code or card terminal. When considering user-friendliness, one might assume Plug & charge is chosen by some CPOs as it is perceived as very user-friendly.

Digitalization is influencing today's development in all market sectors, included EV charging marked, but not all EV drivers are comfortable with digital payment solutions or technologies such as smartphones. From a CPO's perspective, this might be motivation for choosing payment solutions that requires less digital competence, such as RFID chip, card terminal, SMS and Plug & charge. Quality of internet access and tele network vary between locations, and this might be reason for choosing payment solutions such as RFID chip, either CPO-specific or universal, or card terminal, as the EV-user then is not dependent on internet access or telephone reception which is needed when using an app or SMS.

## 5 Influencing steering mechanisms

There are currently both proposed and implemented legislation expected to potentially impact the current situation in Europe regarding charging infrastructure and associated payment solutions. Policies explored in this section are presented by the European Commission and are deemed to impact all EU member states and countries within the EEA. It is consequently essential to be familiar with when considering the potential for a common Nordic solution. Only elements relevant for payment solutions for publicly accessible EV charging will be considered and legislation will not be explored in detail.

### 5.1 Intelligent Transport Systems (ITS): Summary of relevant steering mechanisms for uniformity

The ITS Directive (2010/40/EU) by the European Union from 2010, is a directive to consolidate and unify initiatives regarding Intelligent Transport Systems (ITS) in the EU member states, mostly regarding standardization of frameworks and data exchange. In December 2021, a Directive amending the ITS Directive (2010/40/EU) was published by The European Commission regarding the Framework for the Deployment of Intelligent Transport Systems in the Field of Road Transport and for Interfaces with Other Modes of Transport [42]. The new directive aims at addressing the lack of continuity and interoperability between ITS stakeholders and lack of overall data transparency by advocating for the possibility of making ITS services mandatory in the EU, expanding the scope of the original ITS Directive from 2010 [42].

The proposed directive generally examines the use of different types of data and what data that should be made public between stakeholders, specifically for ITS services regarding road safety and road freight networks [42]. The ITS directive also includes, to some extent, standardization of electronic payments and the interconnection between vehicles and infrastructure [42]. This would imply that the directive would aim for a more uniform solutions and standards in terms of data for electronic payments utilized at public EV charging stations. The very least, ITS would aim to standardize the type of information shared, making it easier to connect solutions and services across borders in EU member states.

ITS also states that the standardization of shared data and information should aim at helping EV drivers making informed decisions by making information accessible and sharable [42]. The new directive indicates that EV drivers, for example, should be able to get information about public charging rates and availability in a more standardized manner [42].

### 5.2 Alternative Fuels Infrastructure Directive (AFID): Summary of relevant steering mechanisms for uniformity

The purpose of AFID, Directive 2014/94/EU of the European Parliament and of the Council from 2014, is to establish a Union-wide harmonized alternative fuels infrastructure [43] and aims to reduce the environmental impact from transportation [43]. The directive presents minimum requirements for all member states regarding developing infrastructure for different types of alternative fuels, where electricity is one of them. Article 4 cover the Electricity supply for transport, where point 9 address the payment solutions for EV charging. The directive states that "All recharging points accessible to the public shall also provide for the possibility for electric vehicle users to recharge on an ad-hoc basis without entering into a contract with the electricity supplier or operator concerned" [43]. Reports does, however, find that this requirement have been implemented in very diverse ways through EU [44].

### 5.3 Proposed Alternative Fuels Infrastructure Regulation (AFIR): Summary of relevant steering mechanisms for uniformity

Market growth of low and zero-emission vehicles is highly needed for a sustainable future, and the European Commission states that further EU action most likely is required to avoid today's recharging and refuelling infrastructure to become a barrier for this development [2]. After evaluating The Alternative Fuels Infrastructure Directive (AFID), The European Commission concluded that adjustments are required to secure that the policy framework support the future climate ambitions [2]. One of the main weaknesses with today's framework is the lack of binding requirements for setting targets and adopting measures, and as a result the level of ambition and supporting policies varies greatly between the member states [2]. Today's recharging and refuelling infrastructure for low- and zero-emission vehicles is unevenly distributed across the Union with no consistency and coherency and the absence of a uniform and easy-to-use payment solution across the European countries is pointed out as one major problem [2].

Due to the limitations of today's policy framework, the European commission have proposed a new regulation for the deployment of alternative fuels infrastructure. The proposed regulation, Alternative Fuels Infrastructure Regulation (AFIR), will repeal AFID when the proposal is approved. The proposal is part of the "Fit for 55" Package, which aim to make EU achieve their ambition of reducing the greenhouse gas emissions with 55 percent from 1990 to 2030 [45].

AFIR aim to make it more convenient to travel with alternative fuel vehicles across EU and one of the regulation's three objectives is "Ensuring full user information and adequate payment options" [2]. To make sure drivers are not met by any surprises anywhere in the EU, information regarding location, accessibility, prices, payments and compatibility is necessary, and adequate payment options should ensure drivers always have a common and easy to use payment option at hand [2].

When looking into steering mechanisms for uniformity of payment solutions, AFIR's article 5 is essential, and second section states that "Operators of recharging points shall, at the publicly accessible recharging points operated by them, provide end users with the possibility to recharge their electric vehicle on an ad-hoc basis using a payment instrument that is widely used in the Union" [2]. This applies to all publicly accessible recharging points that require payment for the recharging service [2]. The regulation distinguishes between charging points with power output below 50 kw and output equal to or more than 50 kw.

AFIR states that operators of recharging points with output less than 50 kW, must accept at least one of the three following payment solutions:

- 1) Payment card readers
- 2) Devices with a contactless functionality that is at least able to read payment cards
- 3) Devices using an internet connection with which for instance a Quick Response code can be specifically generated and used for the payment transaction

For chargers with output equal to or more than 50 kw, 3) is not an option, and the operators must accept 1) payment card readers or 2) devices with a contactless functionality that is at least able to read payment cards [2].

Ensure that driver can use the automatic authentication and may either recharge their vehicle on an ad-hoc basis or use another contract-based recharging solution offered at that recharging point [2].

#### **5.4 Summary of relevant steering mechanisms for uniformity**

All the mentioned steering mechanisms highlights the importance of mobility across the European countries, both for people, businesses and the economy as a whole. ITS, AFID and the proposed AFIR aims to contribute to develop more sustainable transportation across the Union, but while ITS mostly emphasis the safety, AFID and the proposed AFIR draws the attention on the climate perspective.

ITS focus on data uniformity and standardization and aims to provide more easily integrated information interfaces [42]. However, with regards to EV charging and the uniformity of payment solutions, AFID and the proposed AFIR are the most directly relevant. They focus on the importance of being able to charge your car without entering a contract with a charging service provider, i.e. ad-hoc payments. Proposed AFIR highlights even more the importance of a user-friendly payment solution and increases the policy ambition compared to AFID, and at the same time provide more clear requirements for CPOs and MSPs [2].

## 6 Ongoing initiatives in the Nordic countries

All the Nordic countries have implemented initiatives supporting their ambition of a more sustainable transport sector, including initiatives to encourage to buy and use EVs, but the focus on initiatives addressing payment solutions have until now been limited or not existing. Charging service providers have consequently been able to provide the solution with the greatest potential profit, easiest to develop or what they believed to be the future long-term solution. As a result, there is no coherency or uniformity in terms of payment solutions for EV charging.

Ongoing initiatives regarding payment solutions in the Nordic countries have been identified for the Scandinavian countries, but no initiatives have been discovered to the extent of this report for Finland or Iceland. Both payment-oriented initiatives for specific Nordic countries as well as for the entire Nordics will be presented. The purpose of this section is to get a picture of what the future might look like in regards of uniformity, and only initiatives, or part of initiatives, focusing on payment solutions at public charging stations will be described.

### 6.1 Sweden

Two initiatives regarding payment solutions have been identified in Sweden, whereas the first consist of that the former Minister of Energy have put together a group of market actors to initiate a uniform Swedish payment standard. The second initiative are concerning a Swedish roaming platform.

#### **A uniform Swedish payment standard**

To address the fact that the Swedish public charging market's payment solutions are fragmented and ununiform, the current Minister of Energy in Sweden Anders Ygeman invited several market actors to a joint discussion in October 2020 [46]. The goal of the discussion was to agree on a common market strategy forward and the participating actors - including The Swedish Energy Agency, Vattenfall, E.ON, The Swedish Transport Agency, Elbil Sverige among others - was given the task to prepare a proposal until the next meeting that was held 6 months later [46].

The follow-up meeting resulted in some actions being taken in the right direction, but Anders Ygeman reported that the progress is too slow [47]. Instead, Anders Ygeman presented the possibility to take legislative action and propose a new common legislation in Sweden, even more so advocated the Swedish Minister of Energy a common EU standard [47]. No legislation has yet to be proposed and as of November 2021, Sweden has a new Minister of Energy.

#### **Roaming initiative in Sweden**

In terms of payment solutions in Sweden, there are currently a roaming initiative by GreenCharge that aims to set one uniform industry standard for payments in terms of building a platform that lets MSPs, CPOs and other stakeholder connect and utilize their platform [48]. GreenCharge have partnered up with the organization Elbil Sverige and are currently presenting a charging card and app to be utilized cross-functional between connected charging operator as a pilot project for their platform [49] [50]. GreenCharge have partnered up with the roaming platform, Hubject, that is a joint venture of several well-known German car brands including Volkswagen Group and BMW Group, aiming to reach interoperability between different markets [48]. There is yet little result to be presented from the roaming initiatives and few updates have been made in the last year.

### 6.2 Norway

In Norway there are several initiatives ongoing but, related to payment solutions,

two initiatives have been explored further in this chapter. The first initiative is regarding a new National transport plan by The Norwegian Ministry of Transport that identifies several alternatives to create a more uniform payment experience for public EV charging meanwhile the second initiative concerns a universal RFID chip by The Norwegian Electric Vehicle Association.

#### **National transport plan 2022-2033**

There are currently no governmental initiatives addressing payment solutions at publicly accessible charging point in Norway, but The Norwegian Ministry of Transport proposed in March 2021 a transport plan with policies and priorities until 2033 to the Norwegian Parliament. The overall objective is to contribute to an efficient, environmental-friendly, and safe transport system by 2050 [51]. The transport plan points out today's payment solutions for EV charging as confusing and complicated, suggesting that being able to pay with a debit or a credit card could be a solution (chapter 8, page 51) [51]. However, this is currently a recommendation from the Ministry of Transport and it is still

not a requirement made by the Government. Based on suggestions in the transport plan, the Parliament have requested the Norwegian Government to prepare a national charging strategy during 2022 [52]. This strategy should ensure better coordination between public governments and aim to provide a user-friendly charging solution and sufficient charging infrastructure throughout the country [52].

To follow up these requirements and acquire the necessary knowledge, the Norwegian Public Roads Administration have, in collaboration with The Norwegian Environment Agency, recently written a report that will work as input when working out this strategy. The report describes EV charging as confusing and unnecessary complicated, and the lack of uniformity is pointed out as the main problem [53]. Different alternatives are identified to provide a more user-friendly payment environment, including:

- One payment solution across all CPOs, like payment terminals
- Payment solutions based on identification of the car, like Plug & charge
- One customer interface across all CPOs, like roaming might provide

### **New charging chip introduced by The Norwegian Electric Vehicle Association**

Members of The Norwegian Electric Vehicle Association have since 2014 been able to use the same charging chip for an increasing number of CPOs [54]. However, the driver is required to register the chip before use for those CPOs the driver would like to access.

The Norwegian Electric Vehicle Association have recently developed a new RFID chip, which will make the charging process more convenient by enabling charging across operators without registration for the different operators in advance [55]. With the new charging chip, the user needs to register debit/credit card details in The Norwegian Electric Vehicle Association app called "Ladeklubben". To start and stop the charging session, the driver can either use the charging chip from The Norwegian Electric Vehicle Association or the collaborating operators app. As of today, the collaborating operators in Norway are Recharge, Kople, Ionity and E.ON/Clever, but the ambition is to further increase the collaborating network [56].

## **6.3 Denmark**

In Denmark, one initiative related to payment solutions for EV charging have been identified and concerns a legal proposition by the Danish government to promote ad-hoc payments.

### **New law regarding Alternative Fuels Infrastructure**

Denmark have recently adopted a legislative proposal which address payment solutions at publicly accessible charging points. The purpose of the new law is to ensure that Denmark's legislation help achieve today's climate ambitions and to meet the requirements stated by The Alternative Fuels Infrastructure Directive (AFID), described in Chapter 5. [57]. Compared to former laws concerning this area, significant changes have been established and The Danish Ministry of transport found it appropriate to propose a new law addressing alternative fuels infrastructure, rather than making changes in the already existing [57].

The newly implemented law will not be described in detail. Payment options are addressed in Chapter 4 [57] and the law intend to ensure EV-drivers a convenient payment solution, without having to enter a contract with a charging service provider to pay for public charging. The law suggests that charging points placed on public areas or that have been granted public subsidies, should accept electronic payment through terminals or other devices used for payment services. Payment card readers with or without contactless function is mentioned as a minimum requirement, but there are however some exceptions regulated, and operators making use of the exceptions should provide payment solutions by supporting roaming.

## **6.4 All the Nordic countries**

Governmental initiatives concerning all Nordic countries have been described earlier when exploring the European Commission legislation in terms of ITS, AFID and AFIR. This section describes private initiatives related to the public charging infrastructure and payment solutions that might impact all Nordic countries.

### **Common industry standard**

CharIN (Charging Interface Initiative) is an initiative where over 250 different stakeholders in the EV industry have come together to promote a common standard called Combined Charging System (CCS) [58]. The CharIN association was established in 2015 by Audi, BMW, Daimler, Mennekes, Opel, Phoenix Contact, Porsche, TÜV SÜD and

Volkswagen with the common ambition of making CCS the industry standard [59]. Since then, other industry stakeholders have joined representing industries such as energy providers, grid operators, component suppliers, CPOs and car manufacturers [58].

Visa joined the CharIN association in early 2022 and became the first financial partner [60]. The aim of Visa joining is to provide a payment solution standard to CCS that promotes interoperability for customers and easy access, mainly by offering contactless payments by card as a potential standard [60]. Visa, with their experience of payment solutions overall, is considered useful and important to reach payment uniformity [61].

## 7 Analysis

This chapter aims to analyse the eight identified payment solutions in terms of advantages and disadvantages a user, a vendor and a uniformity perspective in accordance with Research objective e). The user perspective explores the benefits and challenges with the different payment solutions affecting the EV-driver, vendor perspective is from a CPO point of view, and uniformity perspective explores the potential for acting as a common Nordic solution. The analysis is based on findings in this report, and it should be noted that all three perspectives are based on desktop research and workshop with Swedish Energy Agency and Sopra Steria. Both user and vendor perspective should be explored further with the relevant parties if it is decided to conduct future research.

In order to better understand the complexity as well as the advantages and disadvantages of the identified payment solutions, each payment solution have been rated as being either "good", "fair" or "poor" from each perspective. This can be summarized in the following table meanwhile further explanation and reasoning behind the rating can be found throughout the rest of this chapter.

	User perspective	Vendor perspective	Uniformity perspective
<b>CPO-specific app</b>	Fair	Good	Poor
<b>Universal app</b>	Good	Fair	Good
<b>CPO-specific RFID chip</b>	Fair	Good	Poor
<b>Universal RFID chip</b>	Fair	Fair	Good
<b>Card terminal</b>	Good	Poor	Good
<b>QR-code/web payment</b>	Fair	Fair	Good
<b>SMS payment</b>	Fair	Fair	Poor
<b>Plug &amp; charge</b>	Good	Fair	Poor

When looking at the advantages and disadvantages of the different payment solutions, universal apps, RFID chips, QR-code/web payment as well as card terminal are the four payment solutions that has the best potential of becoming a uniform solution for the Nordic countries. These options are therefore rated as "good" from a uniformity perspective. One of the main arguments to this is that these solutions, from a technological perspective, have a universal reach. Universal app and card terminal score slightly better than a universal RFID chip and QR-Code/web payments from a user perspective. This is due to the potential in an app to create additional value-added services such as possibility to view availability.

Payments through card terminal is viewed as more favourable from a user perspective as there is no sign-up required and most EV users already have this means of payment available, therefore rated as "good". From a vendor perspective, card terminal is viewed as the least favourable, rated as "poor". This is based on cost of renting terminals, limited access to customer data and use of this, as well as the cost and complexity of installing card terminals on already existing infrastructure.

### 7.1 CPO-specific app

A CPO-specific app is rated as "fair" from a user perspective, "good" from a vendor perspective and "poor" from a uniformity perspective.



### 7.1.1 User perspective

Using a CPO-specific app to pay for charging sessions might provide the user with several benefits. For instance, the user might be offered other services in the app such as possibility to view availability of a charging station. When using app as a payment solution, the driver can also be provided with a charging-log and accordingly have good overview of costs related to all charging sessions. The possibility to start and stop a charging session remotely might also be beneficial, for example in case of bad weather.

As the payment solution is provided by a CPO, users might be offered customer loyalty programs with for instance discounts and other customer benefits that the user might find attractive. From a user perspective, CPO-specific app might be favourable due to trust towards the CPO as many CPOs already have established a strong brand from providing other services (i.e., gas stations and established energy companies).

Payment by app might also be viewed as a future oriented payment solution considering today's digital development. However, all drivers may not prefer a digital solution, and the need for internet access, smartphone and digital competence might be viewed as a disadvantage for app as a payment solution.

CPO-specific apps are among the reasons for why EV drivers are frustrated about today's payment landscape, mainly because EV-drivers report the need to download several apps to have access to enough charging stations. Further, it is often required to sign-up before charging for the first time which can be time consuming and sharing of personal data on several different platforms might in addition be viewed as a negative aspect of CPO-specific apps.

Variation in terms of both services provided and loyalty programs might result in considerable different user experience across different apps which can be confusing for the user. In cases where more than one person usually drives the care, it might be beneficial to be able to share an account between the drivers, this might however be complicated or not even possible with an app as a payment solution.

### 7.1.2 Vendor perspective

From a vendor perspective, a CPO-specific app might be a relatively affordable payment solution, which is easy to update and even expand if the CPO choose to include new services. Customer loyalty might secure the CPO with a relatively predictable income, and customer data makes it possible to customize and improve their app based on the drivers' preferences and increase customer loyalty even further. A CPO-specific app requires limited or no involvement from thirds parties and there is no need to share income with for example roaming platforms or MSPs.

If one or more CPOs introduce new services or improvements, others might need follow to be able to keep or expand their customer base. This might result in a need to hire new competence and will be especially costly for smaller actors. Further, as CPOs main focus is operating charging stations, there might potentially be a lack of focus and investment in their own app, resulting in bad customer experiences and less customers overall.

### 7.1.3 Potential for uniformity

To provide a common Nordic solution for public EV charging, a CPO-specific app would require a monopoly for both CPO and MSP across borders. Due to the negative consequences this solution will represent in terms of competition, prices and services, a CPO-specific app will probably never be evaluated as a possible solution and is consequently evaluated to not be compatible with uniformity.

## 7.2 Universal app

A universal app is rated as "good" from a user perspective, "fair" from a vendor perspective and "good" from a uniformity perspective



### 7.2.1 User perspective

A universal app as a payment solution represents some of the same benefits mentioned for a CPO-specific app, including the possibility to start and stop a charging session remotely and the possibility of offering a wide range of additional services. These services could for example be overview of charging sessions, check availability of and option to reserve charging points. For universal apps, a major benefit is however the possibility to use the app across more than one charging network and the EV driver can choose to use the preferred app with the greatest user experience.

Some of the disadvantages mentioned for CPO-specific app are relevant for a universal app as well. This could be the need for customer sign-up, internet access and digital competence and difficulties in terms of sharing an account

among drivers. As a universal app might be delivered by a MSP not acting as a CPO, users might be charged more for using a third-party payment solution.

### 7.2.2 Vendor perspective

Like mentioned for CPO-specific app, a universal app might be relatively affordable to develop, can be viewed as a future-oriented solution and represents the possibility to collect and use customer data to improve and create services. For universal apps, the work related to development and maintaining the solution can either be outsourced to an MSP or provided by the CPO, based on whatever might be the most favourable solution. Another advantage of having a universal app is a greater chance of gaining more customers as an extended network with more locations can be attractive to a larger customer base than for instance a CPO-specific app.

As mentioned for user perspective, third parties might need to be involved when operating a universal app and in addition share the income. This might also represent other challenges like cooperation and negotiation.

### 7.2.3 Potential for uniformity

A universal app as a payment solution for public EV charging is compatible with uniformity and one common Nordic solution. A Universal app provide EV-drivers access to different charging networks with only one app, and it can be possible to charge across all charging stations in the Nordic countries if made available and technology standardized. A common Nordic solution might be provided by one or more MSPs, but since monopoly should be avoided from a market perspective, more than one operator is preferred in order to create sufficient competition resulting in the best solutions and competitive prices.

A universal app, though, is not considered ad-hoc and are therefore not entirely compatible with the decided and proposed EU legislation on its own. To fulfil the legislation, universal apps would need to be complemented by an ad-hoc payment solution.

## 7.3 CPO-specific RFID chip

7.3.1 A CPO-specific RFID chip is rated as "fair" from a user perspective, "good" from a vendor perspective and "poor" from a uniformity perspective. User perspective



An RFID chip might be considered a user friendly and efficient payment solution as it is easy and quick to use. After registration, there is no need for digital competence, internet access or a smartphone, and the chip can be easily used as a payment solution by more than one driver. Similar to both app solutions, customer loyalty programs and discounts can be provided to the user, but the data is not quite as accessible as for an app where information can be stored and displayed. Some CPO-specific RFID chips require payment in advance where an amount must be deposited when the chip is ordered.

A CPO-specific RFID chip represent some of the same challenges as a CPO-specific app. To access more than one charging network, the driver needs several chips and is required to create several customer accounts. An RFID chip must be obtained in advance and therefore require even more preparation before use compared to an app. Using an RFID chip as a universal solution across borders would require all countries to agree and implement the same solution.

RFID chips have been criticised from a security perspective since they are easy to copy. It also represents one additional item to remember to bring and it might easily be lost, forgotten or stolen. RFID chips do not enable additional services like real time data about available charging stations or the ability to remotely start and stop a charging session.

### 7.3.2 Vendor perspective

From a vendor perspective, a CPO-specific RFID chip will provide the CPO with an overview of existing customer base. Since most RFID chips needs to be ordered in advance and the driver is required to complete a registration beforehand of charging, some degree of customer loyalty is likely to exist. However, compared to CPO-specific app, where the customers might be provided with several services and rewards, customer loyalty is assumed to be considerably lower for CPO-specific RFID chips.

Like mentioned for CPO-specific app, CPO-specific RFID chips might be favourable from a vendor perspective since there are few third parties to share the income with and RFID technology is viewed as relatively affordable to develop. The security risk mentioned under user perspective due to the technology being easy to copy might, however, be challenging to handle from a vendor perspective as well with unhappy customer if affected.

### 7.3.3 Potential for uniformity

To provide a common Nordic solution a CPO-specific RFID chip will, like described for CPO-specific app, require a CPO monopoly across borders and this solution is consequently evaluated to not be compatible with uniformity.

## 7.4 Universal RFID chip

A universal RFID chip is rated as "fair" from a user perspective, "fair" from a vendor perspective and "good" from a uniformity perspective.



### 7.4.1 User perspective

Like described for CPO-specific RFID chip, universal RFID chip as payment solution is efficient, easy to use, does not require internet, smartphone nor digital competence given that registration is completed, and might be used by more than one driver. Universal RFID chip does in addition provide the possibility to use the chip across more than one charging network and the user can choose to only utilize their preferred chip.

Just as for the CPO-specific ones, Universal RFID chips needs to be ordered in advanced. It also requires that the user sign-up and have an account at the RFID chip provider and some solution even requires that you sign up at each CPO to be able to utilize the universal RFID chip. Charging rates might be expected to be higher for universal chip than for CPO-specific, like how it might be for universal vs CPO-specific app, due to involvement of third parties. Further, the RFID chip technology is quite easy to copy, and the chip can easily be lost or forgotten making it less secure and somewhat inconvenient for the user. It is also difficult to utilize add-on services when paying with a RFID chip, for example being unable to see any real-time overview of charging points or control charging sessions remotely.

### 7.4.2 Vendor perspective

From a vendor perspective, universal RFID chips are considered a relatively cheap solution and quite stable operation wise. However, there are some security risks as the RFID chip technology is easy to copy. It also requires an organization that administers the RFID chips and staying in contact with third party actors. As mentioned under user perspective, third parties might need to be involved, and in addition to shared income, this might represent other challenges like cooperation and negotiation.

### 7.4.3 Potential for uniformity

In terms of uniformity, universal RFID chips are regarded as a potential solution since EV drivers can charge at various networks as of today. There are regional differences between countries where some have established universal RFID chip standards that works on most of the charging network within the country already, making it potentially possible to extend these networks on a cross-country level. The Netherlands and Portugal have legislated that all public charging must be connected to one national network already that supports a universal RFID chip standard, showcasing that this can be conducted at the very least on national level.

A similar solution to the Netherlands and Portugal does not require one MSP or one universal RFID chip, but opens for several actors, making it convenient for drivers choosing whichever chip that suits them the best. It could also promote competitive charging rates between the different chips. However, if there are only one or few universal RFID chip available, this could instead increase charging rate and implicate a less convenient user experience. Universal RFID chips are not considered ad-hoc and choosing roaming as a uniform solution for the Nordic countries are not entirely compatible with the decided and proposed EU legislation. This solution would therefore need to be complemented by some sort of ad-hoc payment to be optimal in this perspective.

## 7.5 Card terminal

Card terminals are rated as "good" from a user perspective, "poor" from a vendor perspective and "good" from a uniformity perspective.



### 7.5.1 User perspective

Card terminal is an efficient and easy- to-use payment solution that is the gold standard for payments in general. Given that an EV driver has a debit or credit card, there is no need to sign up to make a customer account or any other preparations, which makes it convenient to pay for charging when traveling with an EV across borders.

From a user perspective, card terminals do not require any internet access, smartphone or digital competence, neither in advance nor during the charging session. Further, as there is no need to sign-up to charge, less personal data is shared with the CPO or MSP which can be viewed as positive.

Using a card terminal as payment solution for EV charging will add another actor to the process, similar to the situation with the universal app and the universal RFID chip. This is likely to result in higher charging prices for EV-drivers compared to CPO-specific solutions and may even result in fewer charging stations being built. Drivers are not provided with any additional services related to EV driving or real time data about charging stations and cannot start and stop their charging sessions remotely.

### 7.5.2 Vendor perspective

Since payment by card is so widespread as a payment solution today, this might provide a potential expansion of the customer base compared to most other payment solutions. However, since there is no lock-in effect, the income might be less predictable compared to payment solutions with different degrees of lock-in effect. Card payments also provide less personal data and detailed customer insight in comparison to payment solutions that requires customers to have an account, which reduces the opportunity to create additional services.

As previously described, card terminal is likely the most expensive choice for the CPO compared to most other described solutions. This cost is related to the terminal itself (monthly fee or upfront investment plus installation cost) but also transaction fees. Offering card terminal as a payment solution in a market where payment by app and other digital solutions have been available, might be seen as reversing the technological development, and therefore not be viewed as a forward-thinking market player.

### 7.5.3 Potential for uniformity

Card terminal is already widespread as a payment solution in other markets than EV charging and is seen as a common Nordic solution in those markets. When considering uniformity and the potential to act as a common Nordic solution for EV charging, ongoing and future initiatives and legislation must be taken into consideration. Since card terminals already is proposed as payment solution in newly implemented and proposed legislation on both national and EU level, card terminal is likely to be implemented to some degree and has the potential to become a common Nordic solution for EV charging. Countries like Germany and Denmark have already taken legislative action to make card terminals a widespread payment solution for EV charging.

## 7.6 QR-code/web payments

QR-code/web payments are rated as "fair" from a user perspective, "fair" from a vendor perspective and "good" from a uniformity perspective.



### 7.6.1 User perspective

From a user perspective, QR-code or other web-based payment solutions does not require any prior sign-up and might be considered as an ad-hoc payment solution. As long as the available payment options are widely recognized and utilized, it could be seen as an efficient and user-friendly payment solution. Further, these types of web payments could refer to a wide array of different payment options, including locally established varieties, such as Swish and Vipps, as well as global options, such as PayPal, Apple and Google pay. However, utilizing QR-code and web payments could potentially lead to higher rates than other payment options due to involvement of third parties.

Equally to app as a payment solution, QR-codes and web payments require a smart phone and internet services, which does not make it ideal in rural areas with less stable internet connection. Further, this solution obliges some digital competence, and that the customer are capable of digital payments. It could also be considered time consuming and not as user-friendly to utilize QR-codes and web payments, since no information is stored in a user account and requires the user to repeat their payment details each time. Dependent on the user interface, this experience could vary greatly, especially as non-digital QR-codes can easily be broken.

## 7.6.2 Vendor perspective

Like utilizing an app, a vendor can easily collect and use customer data to adjust and further develop their services for QR-codes and web payments. However, the lack of customer accounts could make it more difficult in finding patterns and localize the most lucrative target group as well as being unable to communicate offers and campaign material.

From a vendor perspective QR-codes and web payments could, though, be seen as a quite cheap and scalable solutions as it is based on software. It should be easy to add supporting services in the future and update the available payment methods to match the current demand. The lack of customer account and logging would also decrease the amount of needed data storage.

## 7.6.3 Potential for uniformity

In terms of QR-codes and web payments being a potential common Nordic payment solution, it could be considered reasonable as long as drivers have smartphones with Internet access throughout the Nordics. As mentioned, it would also require that available payment options are accessible for all nationalities – either by offering a wide range of different regional or non-regional payment options, or by supporting card payments or equivalent. QR-codes and web payments are seen as an ad-hoc solution, which is compatible with the proposed and determined EU legislation.

## 7.7 SMS payments

SMS payments are rated as “fair” from a user perspective, “fair” from a vendor perspective and “poor” from a uniformity perspective.



### 7.7.1 User perspective

By utilizing SMS as payment option, a user can start and stop a charging session remotely without signing up or create a customer account. SMS payments does not require any smartphone nor any advanced digital competence, however it requires cell reception and knowledge of sending text messages. The charging rates for SMS payments are often higher than for corresponding payment solutions at the same charging station. It could also be difficult for users to keep track of their charging expenses as the amount is charged periodically on the telephone bill. There is also no real-time overview and supporting services that give the user remote insight of the charging.

In the countries where SMS payments are used for EV charging, the local legislation and requirements seems to vary so that some operators require the customer to sign up before being able to utilize SMS payments for charging. From a user perspective, this solution therefore differs between countries and there might be challenging with foreign phone numbers and operators.

### 7.7.2 Vendor perspective

From a vendor perspective, SMS payments utilize the phone operator’s payment infrastructure and process, and there is relatively little need in setting up surrounding payment process, such as customer invoicing. This does, however, require close cooperation with different phone operators and could be quite expensive for vendors as they utilize the operators’ services, resulting in potentially thinner margins.

There is also little customer insight when utilizing SMS payments and it could be difficult to vendors to get to know their customers to develop relevant additional services. Vendors are also very dependent on the services of phone operators and might have limited power in for example price negotiations.

### 7.7.3 Potential for uniformity

In terms of SMS payments being a potential uniform solution in the Nordic countries, it could be a disadvantage that the payment solution is not yet implemented in a majority of the countries. There could also be local regulation regarding phone payments that could make it difficult to make one uniform solution. The current implemented solutions in Sweden, Norway, Denmark and Finland does not seem to support foreign SMS payments, making it quite difficult to make it a current solution at the present stage. However, it might be impossible to develop a solution that supports all the Nordic countries in the future.

## 7.8 Plug & charge

Plug & charge is rated as “good” from a user perspective, “fair” from a vendor perspective and “poor” from a uniformity perspective.



### 7.8.1 User perspective

Plug & charge are regarded as a very user-friendly solution since the entire user experience is mostly automated after signing up. Unlike all other described payment solutions, there is no need for manually starting or stopping the charging session and car manufacturer can secure that the charging is optimized for better battery longevity. The current Plug & charge solution are often heavily integrated with the car user interface which makes it easy for several users utilizing the same charging account as well as there are additional services integrated. Those services could for instance be that the charging station availability is integrated in the car's navigation system and charging capacity could be integrated in route planning.

However, Plug & charge requires customer sign-up and are not considered ad-hoc. There are currently different Plug & charge standards that potentially makes it difficult to find available charging stations and it is only available for specific car brands and models at designated charging stations.

### 7.8.2 Vendor perspective

From a vendor perspective, Plug & charge is a very technical solution that is quite expensive. It could be seen as more of a future-oriented investment since many predict that the automation technology utilized will be more integrated in all types of future charging stations. These investments are often done in fully or partly by car manufacturers why the available solutions today often are car branded. From a car manufacturer perspective, this is further possibility to profit from the EV value chain.

Plug & charge is by EU not considered public charging as it does not support either ad-hoc payments or the majority of EVs. This could, short term, be advantageous as they are not required to support the legislated or proposed standards related to ITS, AFIR and AFID. However, there could be long term difficulties if the market is further regulated and require Plug & charge to conform to current standards. There also seems to be regional differences how Plug & charge are considered which could make for challenging legal interpretations. There are CPOs that offer Plug & charge as an option among other payment solutions and these are, by EU definition, considered as public charging points.

### 7.8.3 Potential for uniformity

Plug & charge as a potential uniform Nordic solution would require support for all car types and models. There is no such solution available yet, and it is reasonable to assume that this type of Plug & charge will take a while to implement and established. Current solutions are working well for travelling abroad and does only require one customer account regardless of market, which makes it a potential solution for uniformity in the future but not as of today.

It is also difficult to predict how legislation will affect Plug & charge in the future as it is currently not considered public charging by the EU and many of its member states. One could interpret that the proposed AFIR legislation will require that all Plug & charge charging stations must support ad-hoc payments in the future.

## 8 Conclusion

The work with this report has confirmed the initial impression of a fragmented market for payment solutions at charging points, both in the Nordic countries and in the European countries included in the report. Eight different payment solutions have been identified and included in the report. An observation is that the fragmentation is not just between payment solutions but also within solutions since it may be necessary not just to have one app for payments but rather five or ten. The same is seen for RFID chips where each CPO may have their own chip that can be used only at their stations. Portugal and the Netherlands differ in this respect since they have instigated laws that require CPOs to connect to a universal app, so called roaming. The app still requires registration and cannot be considered a uniform, ad hoc payment solution although it has some universal features.

Among the Nordic Countries, identified initiatives to harmonize payment solutions on a national level are present in Sweden, Denmark and Norway. As with the proposed and legislated regulations from EU – AFIR and AFID – the identified Nordic initiatives also seem to focus on ad-hoc solutions advocating for the use of card terminals and QR-code/web payments. Norway, on the other hand, has an ongoing initiative by the Norwegian Electric Vehicle Association to create a universal chip potentially connecting all CPOs in Norway, like the legislated roaming in Portugal and The Netherlands. Similar roaming initiatives have also been identified in Sweden, but at a much smaller scale and at a lesser potential geographical range.

There may be several reasons why a CPO chose a certain payment solution, but uniformity does not appear to be a driving force behind the choice. Card terminals, including costs associated with card payment, are considered expensive and are present only to a low extent on the markets included in the report. Other solutions such as apps or RFID chips are cheaper and can provide benefits that are not related to the payment itself. Apps in particular offer the potential to harvest useful data related to charging and create add-on services such as availability of charging space, remote start-and-stop of a charging session and follow up of costs. A customer lock-in effect can also be a reason why a CPO would choose an app or an RFID tag.

Card payment has an outstanding potential for universal payment of EV charging as it is the global standard for monetary transactions, not just within the transportation or EV charging sector. It is also the solution that is included in the proposed AFIR regulation. However, the untapped potential in the value-added services offered through the other solutions should be balanced against the need for a uniform payment solution and several solutions may need to coexist to reach the full potential in EV charging. This implies that a mix of payment solutions may present the best alternative to not only enable easy payment of EV charging today but also capture the full potential of a data driven future.

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## Appendix A – Current EV market distribution

It is useful to have an impression of the development of EV charging in the different countries when considering payment solutions, and some statistic for public EV charging will therefore be presented. It should be mentioned that these numbers are only expected to give an indication and are not sufficient to describe the public EV charging market. The number of charging points is only one element to consider, and these numbers need to be studied in relation to several other factors to gain an understanding of the charging infrastructure and the attractiveness of the national charging network. To mention one additional factor to take into consideration, the need for public charging must be considered in relation to availability of home charging. There are individual differences between the Nordic countries, but in general charging at home is relatively common in the Nordic countries, and since home charging is more convenient and affordable, it might be argued that this reduces the need for public charging compared to other countries [62].

Most of the presented statistics is based on the findings of the Alternative Fuels Observatory why the numbers presented mirrors the EU definition, including what are considered a public EV charging point as well as the EU definition of fast charging points [8].

	Public EV charging points in 2021 [8]	Public fast charging points in 2021 [8]	Fast charging points per 100km highway in 2021 [8]	EV market shares (incl. PHEV) in 2020 [63]
<b>Sweden</b>	14 000	n/a	109	32,2%
<b>Norway</b>	20 000	6 500	1 200	n/a
<b>Denmark</b>	3 500	n/a	52	16,4%
<b>Finland</b>	3 600	724	81	18,1%
<b>Iceland</b>	700	125	340	n/a
<b>Germany</b>	50 000	9 000	70	13,6%
<b>France</b>	32 300	5 200	45	11,2%
<b>Netherlands</b>	82 600	2 800	90	25%
<b>Portugal</b>	3 500	900	28	13,6%

### Sweden

In terms of distribution and accessibility of public EV charging infrastructure, Sweden had approximately 14,000 public EV charging points, corresponding to one charging point per 23 electrical vehicles in 2021 [8]. Further, governmental initiatives for increasing the high-power charging network (>22 kWh) in dispersed areas have rapidly resulted in 109 high-power public charging station per 100 km highway as of 2021 [8]. In comparison, ACEA reported that there were 5 charging points per 100 km of road overall (not only highway) in 2020 and that the market shares for EVs in Sweden were 32,2% [63].

### Norway

Norway had, as of 2021, almost 20,000 charging points, whereof 35% or 6,500 points supports high-power charging [8]. The network and accessibility of high-power charging are considered well-established with approximately 1,200 charging points per 100 km highway in 2021 [8], making it the country within this study with the highest density.

## **Denmark**

Denmark had, as of 2021, approximately 3,500 public EV charging points [8]. In terms of density and accessibility to high-power charging stations, there were 52 charging points per 100 km of highway in 2021 [8], meanwhile a different report stated that there were 4,4 charging points per 100 km road in total (not only highways) as of 2020 [63]. The same ACEA report also specifies that the market share of EVs in Denmark in 2020 were 16,4% [63].

## **Finland**

Even though the amount of plug-in hybrid electrical vehicles (PHEV) is steadily increasing, the amount of EVs is substantially low in Finland [64], ACEA however reports that the market share of EVs in total are 18,1% as of 2020 [63]. There are 3,637 charging points in Finland, as of 2021, where approximately 20% or 724 charging points are high-power that supports fast charging [8]. In terms of accessibility, Finland had in 2021 an average of 81 fast charging points per 100 km of highway according to EAFO [8], compared to an average of 3,3 charging points per 100 km of overall road in 2020 [63].

## **Iceland**

Smaller geographical distances and high accessibility of hydropower and geothermally produced electricity would make Iceland ideal for the adaption of electrical vehicles whereas the mere size of Iceland should be within the driving range of most EVs. Total number of public charging points in Iceland is nearly 700 in 2021, whereas 125 are high-power charging points [8]. With only 37 km of highway, Iceland would have approximately 340 high-power charging points per 100 km highway, as of 2021 [8].

## **Germany**

Germany had, as of 2021, over 50,000 public charging points, whereas approximately 18% or 9,000 high-power charging points supports fast charging [8]. Considering that Germany has 13,000 km of highway, the average number of charging points per 100 km is nearly 400, and if only considering fast chargers, 70 charging points per 100 km [8]. Not considering only highways, there were 19,4 charging points per 100 km road in average as of 2020 and an EV market share of 13,6% [63].

## **France**

The French Government are continuously investing in making public EV chargers more available on the market [65] and the popularity of EV cars is steadily increasing [66]. By the start of 2021 there were nearly 32,300 charging points across France, divided by roughly 27,000 normal charging points and 16% or 5,200 high-power fast charging points [8]. For 11,600 km highway there are, as of 2021, approximately 45 high-power charging points per 100 km highway [8]. In comparison, there were an average of 4,1 charging points per 100 km road overall (not only considering highways) and a EV market share of 11,2% as of 2020 [63].

## **The Netherlands**

The total amount of public charging points in The Netherlands were approximately 82,600 in 2021, whereas roughly 3,5% or 2,800 are high-power charging points [8]. With just above 3,000 km of highway, Netherland have more than 2,600 charging points per 100 km if considering all public charging points and approximately 90 high-power charging points per 100 km, as of 2021 [8]. Considering all roads, there were an average of 47,5 charging points per 100 km in 2020 [63].

The number of charging points is steadily increasing though and the Dutch government continuously work on expanding the charging network to incentivize the population to drive electric and residents can in many areas openly request for public charging points to be installed [67] [68]. As of 2020, the total market shares for EVs were approximately 25% [63].

## **Portugal**

As of 2021, there are approximately 3,500 public charging points in Portugal, whereas 25% or 900 charging points are high-power that supports fast charging [8]. Considering the number of charging points in relation to Portugal's 3,000 km of highway, there is approximately 112 charging points and 28 high-power charging points per 100 km highway in 2021 [8]. In terms of accessibility on all types of roads, there were in 2020 14,9 charging points per 100 km road [63]. The same year, the market shares of EVs in Portugal was 13,6% [63].

## Appendix B – Current payment solutions at the public EV charging market

### Sweden

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>InCharge</b> (Vattenfall)	App, RFID chip	CPO and MSP	4000+ charging points in Sweden	"InCharge app"	A InCharge RFID chip works on both InCharge's and E.ON's network	<a href="https://incharge.vattenfall.se/ladda-pa-vagen/bestall-laddkort">https://incharge.vattenfall.se/ladda-pa-vagen/bestall-laddkort</a>
<b>Göteborgs Energi</b>	App	CPO and MSP	15 chargers (+50kWh), +1000 chargers with lower capacity in Sweden	"Ladda din elbil"		<a href="https://www.goteborgenergi.se/privat/ladda-elbil/laddkarta">https://www.goteborgenergi.se/privat/ladda-elbil/laddkarta</a>
<b>Fortum</b>	App, SMS, RFID chip	CPO and MSP	2700 charging points in the Nordic countries (also apart of the Recharge network)	"Fortum Charge & Drive"		<a href="https://www.fortum.se/">https://www.fortum.se/</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://my.newmotion.com/">https://my.newmotion.com/</a>
<b>Plugsurfing</b>	App, RFID chip	MSP	250 000 charging points in Europe, Part of the Recharge network	"Plugsurfing app"		<a href="https://plugsurfing.com/drivers-travellers-solutions/">https://plugsurfing.com/drivers-travellers-solutions/</a>
<b>Circle K</b>	App, Card terminal	CPO and MSP	Lower prices if you sign up in the app vs. Ad-hoc charging	"Circle K charge"	Mer, Ionity (will be able to use these chargers with the app in the future)	<a href="https://www.circlek.se/station-search">https://www.circlek.se/station-search</a>
<b>Mer</b>	App, RFID chip	CPO and MSP	500 charging points in Sweden. The Swedish app work in the Norwegian Mer network	"Mer Connect Sverige"	Mer Connect Norway	<a href="https://se.mer.eco/snabbladdning/laddkarta/">https://se.mer.eco/snabbladdning/laddkarta/</a>
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>Virta</b>	App, RFID-chip, Web payments	MSP	In 30+ countries, "thousands of stations"	"Virtas Mobilapp"		<a href="https://www.virta.global/sv/elbilsanvandare">https://www.virta.global/sv/elbilsanvandare</a>
<b>OKQ8</b>	App	CPO and MSP	1000 charging points available in Sweden, 10 000+ in Europe	"OKQ8 Elbilsaddning"	Skellefteå kraft	<a href="https://www.okq8.se/hem-forsakring/ladda-elbil/ladda-pa-vagen/">https://www.okq8.se/hem-forsakring/ladda-elbil/ladda-pa-vagen/</a>

<b>E.ON Drive</b>	App, RFID chip	CPO and MSP		"E.ON Drive"	Roaming partners with Vattenfall	<a href="https://eondrive.eon.se">https://eondrive.eon.se</a>
<b>Tesla</b>	Plug & charge	CPO and MSP				
<b>EasyPark</b>	App	MSP	Part of the Recharge network	"EasyPark App"	Recharge, E.ON, Göteborg Energi	<a href="https://www.easyparkgroup.com/our-offer/offer-electric-vehicle-charging/">https://www.easyparkgroup.com/our-offer/offer-electric-vehicle-charging/</a>

## Norway

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Tesla</b>	Plug & charge	CPO			Elbilforeningen	<a href="https://www.tesla.com/no_NO/support/non-tesla-supercharging">https://www.tesla.com/no_NO/support/non-tesla-supercharging</a>
<b>Eviny (Bilkraft)</b>	App, RFID chip, QR-code, SMS payments?	CPO and MSP	Support "Vipps" payments in the app	"Bilkraft"	Elbilforeningen	<a href="https://bilkraft.no/faq/no.html">https://bilkraft.no/faq/no.html</a>
<b>Kople</b>	App, RFID chip, QR-code/web payments	CPO and MSP		"Kople"	Current partners: <a href="https://www.kople.no/lad-elbil-og-andre-apper-til-efylling">https://www.kople.no/lad-elbil-og-andre-apper-til-efylling</a>	<a href="https://www.kople.no/veiledning/dropin">https://www.kople.no/veiledning/dropin</a>
<b>E.ON</b>	App, RFID chip	CPO and MSP	Able to register other RFID chips to support E.ON charging	"E.ON Drive App"	Elbilforeningen	<a href="https://eondrive.no/">https://eondrive.no/</a>
<b>InCharge (Vattenfall)</b>	APP, RFID	Charging operator	22 000 charging points in Norway, Sweden, Germany and Netherlands	"InCharge App"	Elbilforeningen	<a href="https://incharge.vattenfall.no/en/charge-on-the-go">https://incharge.vattenfall.no/en/charge-on-the-go</a>
<b>Mer</b>	App, RFID chip, QR-code/web payments, SMS payments	CPO and MSP	Support "Vipps payments".  Over 670 fast charging points in Norway	"Mer Connect"		<a href="https://no.mer.eco/pris/">https://no.mer.eco/pris/</a>
<b>Elbilforeningen</b>	App, RFID chip	MSP	Approx. 1200 charging points in Norway	"ElbilAppen"	Collaborate with most networks in Norway	<a href="https://elbil.no/faq-cat/elbilforeningens-ladebrikke/">https://elbil.no/faq-cat/elbilforeningens-ladebrikke/</a>
<b>Circle K</b>	App, RFID chip, QR-code	CPO and MSP	+550 charging points in Norway	"Circle K Charge"	Provide their own charging points but have also Ionity, Mer and Tesla present at their stations	<a href="https://www.circlek.no/elbilladning/ladestasjoner">https://www.circlek.no/elbilladning/ladestasjoner</a>
<b>Ishavsveien</b>	App, RFID chip	CPO and MSP	26 fast charging stations	"Ishavsveien"	Collaboration between Ishavskraft AS and Vattenfall InCharge	<a href="https://www.ishavsveien.no/">https://www.ishavsveien.no/</a>
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>

<b>NAF ladebrikke</b>	RFID chip	MSP	The RFID chip must be registered at each operator			<a href="https://www.naf.no/medlemskap/medlemsfordeler/naf-ladebrikke/">https://www.naf.no/medlemskap/medlemsfordeler/naf-ladebrikke/</a>
<b>Bertl O. Steen</b>	RFID chip	MSP			Mer	
<b>Møller bil</b>	RFID chip	MSP	The RFID chip must be registered at each operator		Mer, BKK, Lyse, Fortum, Circle K, Ionity, Kople, Lade i Norge	<a href="https://mollerbil.no/elbil/ladebrikke/">https://mollerbil.no/elbil/ladebrikke/</a>
<b>Lade i Norge</b>	RFID chip, Web payments, SMS payments	MSP	All charging stations I this network are owned privately. Everyone can offer their charging point by connecting to OCPP			<a href="https://ladeinorge.no/">https://ladeinorge.no/</a>
<b>Elton</b>	App, QR-code	MSP	Support "Vipps" payments	"Elton"	Recharge (Fortum), Kople, E.ON og Ionity i Norge og Sverige	<a href="https://elton.app/">https://elton.app/</a>
<b>Plugsurfing</b>	App, RFID chip	MSP	250 000 charging points in Europe, Part of the Recharge network	"Plugsurfing app"		<a href="https://plugsurfing.com/drivers-travellers-solutions/">https://plugsurfing.com/drivers-travellers-solutions/</a>
<b>Recharge</b> (earlier Fortum Charge & Drive)	App, RFID chip, QR-code/web payments, SMS payments	CPO and MSP	2700 charging points in the Nordic countries (also apart of the Recharge network)	"Fortum Charge & Drive"	Partners: <a href="https://rechargeinfra.com/no/kundeservice/">https://rechargeinfra.com/no/kundeservice/</a>	<a href="https://www.fortum.com/media/2020/04/fortum-partners-infracapital-speed-charging-infrastructure-development-and-growth">https://www.fortum.com/media/2020/04/fortum-partners-infracapital-speed-charging-infrastructure-development-and-growth</a>
<b>Chargemap</b>	RFID chip	MSP	450,000 charge points across Europe with a Chargemap pass			<a href="https://chargemap.com/pass">https://chargemap.com/pass</a>
<b>Easypark</b>	App	MSP	Part of the Recharge network	"EasyPark App"		<a href="https://easypark.no/help/no/3421">https://easypark.no/help/no/3421</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://newmotion.com/no-no/stotte/ofte-stilte-sporsmal/ladekort">https://newmotion.com/no-no/stotte/ofte-stilte-sporsmal/ladekort</a>

## Denmark

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Tesla</b>	Plug & charge	CPO and MSP				
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>E.ON</b>	App, Web payments, RFID chip	CPO and MSP	As an E.ON customer, you can charge your electric car in one of the largest charging network in Denmark, with 1,600 public charging points. .	"E.ON Drive App"	EasyPark app	<a href="https://www.eon.dk/in-english/easypark.html">https://www.eon.dk/in-english/easypark.html</a>
<b>Clever</b>	App, RFID chip, Card terminal	CPO and MSP	More than 900 charging points in Denmark, Sweden, and Northern Germany	"Clever"		<a href="https://intercom.help/cleverdenmark/da/articles/5355624-hvordan-starter-jeg-en-opladning-med-clevers-app-som-ikke-kunde">https://intercom.help/cleverdenmark/da/articles/5355624-hvordan-starter-jeg-en-opladning-med-clevers-app-som-ikke-kunde</a>
<b>Sperto</b>	RFID chip, Web payments	CPO and MSO	They call themselves "public" and willing to connect with other networks			<a href="https://www.sperto.dk/opladning/betalingsstile/">https://www.sperto.dk/opladning/betalingsstile/</a>
<b>Spirii</b>	App	MSP	A platform provider that wants other actors to connect. A part of the European roaming platform Hsubject, which offers roaming on more than 200,000 charging points	"Spirii Go"	Hsubject	<a href="https://spirii.com/products-overview/charging-network/">https://spirii.com/products-overview/charging-network/</a>
<b>Plugsurfing</b>	App, RFID chip	MSP	250 000 charging points in Europe, Part of the Recharge network	"Plugsurfing app"		<a href="https://plugsurfing.com/drivers-travellers-solutions/">https://plugsurfing.com/drivers-travellers-solutions/</a>
<b>EVBox</b>	App	CPO and MSP	EVBox, manufacturer of smart and scalable charging stations. Offers both charging points, software and services	"EVBox Charge"	Norlys software: "Everon"	<a href="https://news.evbox.com/en-WW/201875-norlys-signs-multi-year-partnership-with-evbox-group-to-boost-electric-">https://news.evbox.com/en-WW/201875-norlys-signs-multi-year-partnership-with-evbox-group-to-boost-electric-</a>

**NewMotion**  
(will be  
renamed as  
Shell Recharge  
Solution)

App, RFID chip

CPO and  
MSP

Part of the  
Recharge network,  
over 250 000  
charging points in  
Europe

"Shell Recharge  
App"

mobility-across-  
denmark

[https://my.new  
motion.com/](https://my.newmotion.com/)

## Finland

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Tesla</b>	Plug & charge	CPO				<a href="https://www.tesla.com/findus/list/superchargers/Finland">https://www.tesla.com/findus/list/superchargers/Finland</a>
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>Recharge</b> (earlier Fortum Charge & Drive)	App, RFID chip, QR-code/web payments, SMS payments	CPO and MSP	2700 charging points in the Nordic countries (also apart of the Recharge network)	"Fortum Charge & Drive"		
<b>Virta</b>	App, RFID chip, Web payments	CPO and MSP	Largest public charging network in Finland	"Virta"	NewMotion	<a href="https://tele2iot.com/case/global-electric-vehicle-charging-infrastructure-from-virta/">https://tele2iot.com/case/global-electric-vehicle-charging-infrastructure-from-virta/</a>
<b>Helen Lataus</b>	App, RFID, Web payments	CPO and MSP	Supports Virta app, doesn't have any of their own		Virta	<a href="https://www.helen.fi/en/electric-cars/charging-network">https://www.helen.fi/en/electric-cars/charging-network</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://my.newmotion.com/">https://my.newmotion.com/</a>

## Iceland

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>On Power</b>	RFID chips, App (only provided by others)	CPO and MSP	Over 100 charging points on Iceland	"ON Hleðsla"	Plugsurfing	<a href="https://www.on.is/en/electric-vehicles/charging-points/">https://www.on.is/en/electric-vehicles/charging-points/</a>
<b>Recharge</b> (earlier Fortum Charge & Drive)	App, RFID chip, QR-code/web payments, SMS payments	CPO and MSP	2700 charging points in the Nordic countries (also apart of the Recharge network)	"Fortum Charge & Drive"	Collaborate with ON Power	<a href="https://www.fortum.com/media/2016/07/fortum-charge-drive-expand-collaboration-power-iceland">https://www.fortum.com/media/2016/07/fortum-charge-drive-expand-collaboration-power-iceland</a>
<b>EVBox</b>	App	CPO and MSP	EVBox, manufacturer of smart and scalable charging stations. Offers both charging points, software and services	"EVBox Charge"	Collaborate with ON Power	<a href="https://www.electrive.com/2021/04/20/evbox-on-power-expand-iceland-charging-network/">https://www.electrive.com/2021/04/20/evbox-on-power-expand-iceland-charging-network/</a>
<b>Orkusalan</b>	RFID chip	CPO and MSP	80 charging points on Iceland			<a href="https://www.orkusalan.is/hledslustodvar">https://www.orkusalan.is/hledslustodvar</a>
<b>Tesla</b>	Plug & charge	CPO and MSP				
<b>Plugsurfing</b>	App, RFID chip	MSP	250 000 charging points in Europe, Part of the Recharge network	"Plugsurfing app"		<a href="https://plugsurfing.com/drivers-travellers-solutions/">https://plugsurfing.com/drivers-travellers-solutions/</a>

## Germany

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Allego</b>	App, RFID chip, Card terminal	CPO and MSP	More than 28 000 charging points in Europe	"Smoov"	Over 100 partners in Europe	<a href="https://www.allego.eu/new-tariffs-2022">https://www.allego.eu/new-tariffs-2022</a>
<b>Smoov</b>	App	MSP			Allego	<a href="https://smoovapp.eu/">https://smoovapp.eu/</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://my.newmotion.com/">https://my.newmotion.com/</a>
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>Tesla</b>	Plug & charge	CPO and MSP				<a href="https://www.tesla.com/en_eu/supercharger">https://www.tesla.com/en_eu/supercharger</a>
<b>Plugshare</b>	App	MSP	Gather charging stations from all over the world	"Plugshare"	Several big operators such as Tesla	<a href="https://www.plugshare.com/">https://www.plugshare.com/</a>
<b>Chargemap</b>	RFID chip	MSP	450,000 charge points across Europe with a Chargemap pass			<a href="https://chargemap.com/pass">https://chargemap.com/pass</a>
<b>InCharge</b> (Vattenfall)	App, RFID chip	CPO and MSP	+22 000 charging points in Sweden, Norway, Germany and Netherlands	"InCharge app"		<a href="https://incharge.vattenfall.se/en">https://incharge.vattenfall.se/en</a>
<b>Plugsurfing</b>	App, RFID chip	MSP	250 000 charging points in Europe, Part of the Recharge network	"Plugsurfing app"		<a href="https://plugsurfing.com/drivers-travellers-solutions/">https://plugsurfing.com/drivers-travellers-solutions/</a>

## France

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Tesla</b>	Plug & charge	CPO and MSP				
<b>Fastned</b>	App, RFID chip, QR-code/web payments, Plug & charge	CPO and MSP	+100 fast charging stations in Netherlands, Germany and other European countries	"Fastned app"	Have bought Mistergreen	<a href="https://support.fastned.nl/hc/en-gb/articles/209499838-How-can-I-pay-at-Fastned-">https://support.fastned.nl/hc/en-gb/articles/209499838-How-can-I-pay-at-Fastned-</a>
<b>Chargemap</b>	RFID chip	MSP	450,000 charge points across Europe with a Chargemap pass			<a href="https://chargemap.com/pass">https://chargemap.com/pass</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://my.newmotion.com/">https://my.newmotion.com/</a>
<b>Plugshare</b>	App	MSP	Gather charging stations from all over the world	"Plugshare"	Several big operators such as Tesla	<a href="https://www.plugshare.com/">https://www.plugshare.com/</a>
<b>IZIVIA</b>	App, RFID chip	CPO and MSP	IZIVIA becomes the first French operator with an interoperable charging network thanks to the GIREVE platform	"IZIVIA"		<a href="https://www.izivia.com/carte-borne-recharge-izivia">https://www.izivia.com/carte-borne-recharge-izivia</a>
<b>Kiwhi</b>	RFID chip	MSP	43,000 charging points, i.e. 93% of the national network accessible with Kiwhi Pass card			Lokasjoner: <a href="https://www.kiwhipass.fr/#art6">https://www.kiwhipass.fr/#art6</a>
<b>Allego</b>	App, RFID chip, Card terminal	CPO and MSP	More than 28 000 charging points in Europe	"Smoov"	Over 100 partners in Europe	<a href="https://www.allego.eu/new-tariffs-2022">https://www.allego.eu/new-tariffs-2022</a>
<b>Belib</b>	App, RFID chip, Card terminal	CPO and MSP	411 charging points available in Paris, France. Better rates for owners of Belib's RFID chip and/or residents of Paris	"BELIB"		<a href="https://belib.paris/home">https://belib.paris/home</a>
<b>TotalEnergies</b>	RFID chip, QR-code/web payments	CPO and MSP	+100 fast charging station in France, also stations in Germany, Belgium and Netherlands		A list of RFID chips accepted:	<a href="https://evcharge.totalenergies.com/en/you-are-you-are-ev-driver">https://evcharge.totalenergies.com/en/you-are-you-are-ev-driver</a>

## The Netherlands

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Allego</b>	App, RFID chip, Card terminal	CPO and MSP	More than 28 000 charging points in Europe	"Smoov"	Over 100 partners in Europe	<a href="https://www.allego.eu/new-tariffs-2022">https://www.allego.eu/new-tariffs-2022</a>
<b>Tesla</b>	Plug & charge	CPO and MSP	Opens up for third parties in NL			<a href="https://www.tesla.com/findus/list/superchargers/Netherlands">https://www.tesla.com/findus/list/superchargers/Netherlands</a>
<b>InCharge</b> (Vattenfall)	App, RFID chip	CPO and MSP	+22 000 charging points in Sweden, Norway, Germany and Netherlands	"InCharge app"		<a href="https://incharge.vattenfall.se/en">https://incharge.vattenfall.se/en</a>
<b>NewMotion</b> (will be renamed as Shell Recharge Solution)	App, RFID chip, Card terminal	CPO and MSP	Part of the Recharge network, over 250 000 charging points in Europe	"Shell Recharge App"		<a href="https://my.newmotion.com/">https://my.newmotion.com/</a>
<b>Fastned</b>	App, RFID chip, QR-code/web payments, Plug & charge	CPO and MSP	+100 fast charging stations in Netherlands, Germany and other European countries	"Fastned app"	Have bought Mistergreen	<a href="https://support.fastned.nl/hc/en-gb/articles/209499838-How-can-I-pay-at-Fastned-">https://support.fastned.nl/hc/en-gb/articles/209499838-How-can-I-pay-at-Fastned-</a>
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Collaborates with car brands and other MSP charging cards	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>Tango</b>	App, RFID chip	CPO and MSP	RFID chip covers most charging points in NL	"Tango electric app"	Part of Q8	<a href="https://www.tango.nl/electric-particulier">https://www.tango.nl/electric-particulier</a>
<b>E-Flux</b>	RFID chip	MSP	They provide their "E-Flux" RFID card, 99% coverage in the NL			<a href="https://www.e-flux.nl/en/e-flux-mobility-cards/">https://www.e-flux.nl/en/e-flux-mobility-cards/</a>

## Portugal

Actor	Payment solution	Type of actor	Comments	App	Partner	Link
<b>Ionity</b>	App, QR-code/web payments, Plug & Charge	CPO and MSP	404 locations in Europe "Fast charger every 100 miles on all European highways"	"IONITY App"	Part of the national Mobi.e network  Collaborates with car brands and other MSP charging cards.  Cepsa partnership?	<a href="https://ionity.eu/">https://ionity.eu/</a>
<b>Tesla</b>	Plug & charge	CPO and MSP			Part of the national Mobi.e network	
<b>KLC</b>	App, RFID chip	CPO			Part of the national Mobi.e network	<a href="https://www.kmlowcost.com/en/our-client">https://www.kmlowcost.com/en/our-client</a>
<b>Miio</b>	App, RFID chip	MSP	Seems to support almost all charging points within the Mobi.e network	"miio"	Part of the national Mobi.e network	<a href="https://www.miio.pt/en#miio-pay">https://www.miio.pt/en#miio-pay</a>
<b>Galp</b>	RFID chip	MSP			Part of the national Mobi.e network	<a href="https://galp.com/pt/">https://galp.com/pt/</a>
<b>Repsol</b>		CPO? (no payment options by Repsol)	More than 1000 charging stations in Portugal and Spain		Part of the national Mobi.e network  Partner with Uber	<a href="https://www.mobie.pt/en/rede-mobie/procurar-posto">https://www.mobie.pt/en/rede-mobie/procurar-posto</a>
<b>Prio</b>	RFID chip	CPO and MSP	67 charging stations in Portugal		Part of the national Mobi.e network	<a href="https://www.prio.pt/en/prio-stations_289.html?tab=1&amp;type=2h">https://www.prio.pt/en/prio-stations_289.html?tab=1&amp;type=2h</a>